Thirty Years of 3M's Pollution Prevention Program

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ABSTRACT

This article presents a retrospective of thirty years of 3M's pioneer "Pollution Prevention Pays", better known for insiders as the 3P program. Firstly, the article revises the evolution of environmental management from Pollution Control to Pollution Prevention and describes how Dr. Joseph Ling created and structured the 3P program. Secondly, it is analyzed how the 3M's pollution prevention experience was broadly diffused in partnership with the United Nations and with the U.S. Environmental Protection Agency. Thirdly, the article discusses the recent evolutions in the 3P program and how it increased its environmental results, by establishing synergy with a corporate initiative for implementing a project management organizational structure and a structured project management methodology. Finally, it is presented a detailed case study of the 3P program in the Brazilian subsidiary.

Key words: Pollution prevention; 3M; Joseph Ling, Six Sigma.

1. Introduction

"Pollution is waste, and waste today leads to shortages tomorrow.".
PhD. Joseph Ling

The 3M's Pollution Prevention Pays (3P) Program completes thirty years of continuous improvements for improving environmental performance. The aggregated results from the first year of each of the 5,600 3P projects since 1975 account 2.2 billion pounds of pollutants prevented and 1 billion dollars saved.

The basic idea of the program is employees' volunteer engagement to improve products and production processes, in order to prevent pollution at the source.

In the sixty's, regulatory agencies were focused on the pollution control approach. In this sense, companies utilized additional equipments in the productive process for removing pollution, before it damaged the natural environment. However, in most of the cases of pollution control, pollutants do not disappear, but just are transformed in another category of pollutants (LING, 1997).

In 1975, the 3M 3P Program pioneered with the concept of adopting pollution prevention in the whole corporation and registering the results. The program was launched with a broad internal communication action with a video of the CEO promoting 3P for the technical and manufacturing publics. Moreover, the creator of the 3P program, Dr. Joseph Ling, personally divulgated the 3P program in executives and managers meetings.

After the first year of existence, the Pollution Prevention Pays program concluded 19 projects, which reported 1.5 million pounds of pollution prevented and 11 million dollars saved.

The United Nations invited 3M to present its pollution prevention approach in 1976 at an international conference in Paris. In 1977, 3M jointed the US-Environmental Protection Agency to conduct four conferences on pollution prevention. In the next years, countries as United Kingdom, France and Germany adopted pollution prevention concepts in their environmental policies and, in 1990, the U.S. Pollution Prevention Act was created based also on the 3P program experience.

The 3P program creator, Dr. Joseph Ling, is recognized as the father of pollution prevention programs (SORENSON, 1999). Ling was born in 1919, in Peking, China, and received a Ph.D. degree from the University of Minnesota in sanitary engineering. Back in China in 1956, Dr. Joseph Ling organized the National Institute of Sanitary Engineering Research in Peking and became its first director (SORENSON, 1999). Dr. Ling jointed 3M in 1960 and retired as vice president after a 24 years career.

Many companies have imitated 3M's 3P program. "The idea of 3P was unheard of when it was first introduced," said Jim McNerney, CEO. "Once again, 3M was acting as a leader, only this time within the pollution prevention arena. Just like the creation and development of sandpaper, Scotch® brand Tape, Post-it® Notes or Aldara™, we look at 3P as one of our proudest achievements."

2. Recent Developments in the 3P Program

The Pollution Prevention Program is conducted by a Coordinating Committee, composed by representatives of 3M's engineering, manufacturing and laboratory organizations together with the Environmental, Health and Safety department. This Coordinating Committee defines the 3P award criteria and recognizes projects with the 3P awards.

In order to be recognized as a Pollution Prevention Pays project it must at least reduce a pollutant (or reduce energy use) and save money, by eliminating or reducing the need to utilize pollution control equipment or by reducing operating and materials expenses or even by increasing sales.

In 2002, the 3P program was reformulated, in order to obtain engagement of more functional areas. For this purpose, the program defined special recognition categories for logistics, packaging and also for the implementation of Life Cycle Management tools.

In addition to the awards, participation in the program is also motivated by the corporate environmental goals allocated for the operational divisions

3P projects not only prevented pollution, but also triggered innovation, resulting in patented pollution prevention technologies. For example, the solventless process is a 3M technology to reduce air emissions for many products from tapes to sandpaper, which enabled more than half of the company's air emissions reductions in the last thirty years.

"3M's 3P program has been successful beyond anyone's expectations," said Keith Miller, manager of Environmental Initiatives and Sustainability. "Early on, it was expected that we might run out of pollution prevention ideas after a few years. The opposite has occurred." In fact, 3P project submissions from employees worldwide from 2000 to 2004 were more than double the five-year target, with a record of 896 projects already submitted. "A fresh mix of new and ingenious ways to prevent releases to air and water, reduce waste, conserve energy, and save resources keep flowing in from employee teams around the world," Miller said.

3. Examples of Innovative 3P Projects

3P project teams developed the following products and technologies:

- An office tape was reformulated thirty years ago, when the adhesive was made with water-based rather than a solvent-based process. Surgical tapes now are manufactured with a patented hot-melt process that eliminates 2.3 million pounds of solvents each year and reduces energy consumption by 77 percent.
- 3M Germany developed a solventless adhesive manufacturing system for the reflective material used in traffic signs. This prevents the generation of more than 1,000 tons of solvent air emissions annually.
- Post-it® Notes are made from 100 percent de-inked, recycled fiber with 20 percent post-consumer waste, by weight. This product was created in response to customer requests for high-quality, recyclable notes.
- For more than five years, eighty 3M United Kingdom employees developed an asthma inhaler that contains no chlorofluorocarbons, an ozone-depleting chemical. Many substitutes had to be rejected because they were toxic or flammable, or incompatible with the drugs.
- 3M's Cottage Grove, Minnesota, facility developed a collapsible, reusable steel crate that reduces waste and saves money. Prior to the development of this 3P project, all shipments of automotive products to Germany went in a multi-piece wooden crate. When received in Germany, the automotive products were removed from the crate and the crate thrown away. An employee team looked at many alternatives to reduce waste from these shipments and selected the idea of using returnable packaging. The team worked with an outside contractor to build prototypes for testing. The final design had to be robust to hold 1,800 pounds of product, double stacked in a shipping container.

As a result, the new crates are made of steel and collapse to one-third of their height for the return trip to the US. The team's work eliminated 315 tons of solid waste and produced $101,800 savings.

- 3M's Alexandria, Minnesota, facility reformulated its process for producing abrasive backing. The new process improves product performance and consistency, and nearly eliminates air emissions. This project prevented three tons of air pollution and saved $45,000 in its first year.
- In France, 3M developed and installed a new decking system in the trucks that transport finished products from the plant. The decking system allows the plant to pack more materials into any one truck. The system is made of adjustable racks that can be easily and quickly assembled while pallets are loaded. The decking system enables one truck to carry two levels of load without stacking the pallets on each other and damaging the products. This new system has reduced the number of daily truckloads by 40 percent, saving about 12,500 gallons of fuel and $110,000 per year.

4. The Six Sigma Methodology

In 2001, 3M adopted a project management methodology and a organizational structure for improving business processes: the Six Sigma methodology. For this reason, 3M trained more than 36 thousand salaried employees, who, in year 2004, closed more than 12 thousand Six Sigma projects for improving processes and saving costs.

The Six Sigma methodology improved 3M's project management capacity and, therefore, proved to be an effective approach for increasing the number of Pollution Prevention Pays projects.

Pande, Neuman and Cavanagh (2001) describe how Motorola and GE implemented the Six Sigma methodology, which defines:

a) An organizational structure for project management;
b) Project management structure phases;
c) And a sequence of analytical and organizational tools for conducting improvement projects.

The main role in Six Sigma is that of the project manager called "Black Belt" in analogy to the oriental fights that define different belts to signalize level of proficiency. This project manager is responsible to lead a project and to statistically validate the independent variables (project Xs) that most impact the project dependent variable behavior (project Y) (PANDE, NEUMAN and CAVANAGH, 2001).

In order to achieve this diagnosis and the improvements, the project team must structure the project in phases of: project definition, current performance measurement, analysis of the independent variables, independent variables improvements, and independent variables control procedures (PANDE, NEUMAN and CAVANAGH, 2001):

1. Define – A project begins with a statement about the problem to be solved.

2. Measure – In this phase, the team measures the actual performance of the project dependent variables (Ys) in a time series.

3. Analyze – In the analytical phase, the project team identifies the potential independent variables (project Xs), prioritizes them and quantifies their explaining power for the Y behavior.

4. Improve – Once the independent variables (project Xs) are proved in the Analyze phase, the team manipulates the Xs, in order to experimentally optimize the process parameters in a prototypic solution.

5. Control – Finally, the project team creates new work procedures and new roles and responsibilities, in order to ensure continuous maintenance of the improved performance.

In each Six Sigma phase, the project team utilizes the following tools (PANDE, NEUMAN and CAVANAGH, 2001):

- Define – In this phase, the team utilizes the Project Charter, in which all organizational areas involved with the project define the project team members roles, the project metrics, scope and due date.

- Measure – The team measures the project dependent variable (project Y) using statistical tools for quantifying how much the Y behavior is due to the process variation and how much it is due to error in the measurement system (gages and peoples measuring the variable).

- Analyze – In this phase, the team describes the business process in the project scope by means of Process Maps, which captures all potential independent variables (project Xs). Then the Xs are prioritized and the selected Xs are checked for failure risk with the FMEA (Failure Mode and Effect Analysis). In this manner, the most critical Xs are qualitatively found and, then, they must be statistically proved by means of Multi-variables Study (Regression, ANOVA, T-tests, and other statistical tools). The project team finalizes the Analyze phase with conclusions about the process diagnosis.

- Improve – The team already knows which are the independent variables (project Xs) that may improve the business process, but the team must also demonstrate the optimized performance in a simulation or in experimentation with DOE (Design of Experiments).

- Control – Finally, the team utilizes statistical tools for monitoring the improved Y and Xs. Moreover, the team documents the new work procedures and trains the operational employees how to maintain the improved performance.

5. The 3P Program in Brazil: Six Sigma for Environment

In Brazil, fifty-six 3P projects were concluded from 2001 to 2005, resulting in 54 thousands tons of pollution prevented and US$ 6.5 millions savings.

The manager responsible for the 3P program in Brazil states that the Six Sigma methodology demonstrated to be an effective tool for making the 3P program work. In fact, many of the Six Sigma projects prevent pollution and save costs, so that those projects meet the criteria for receiving the 3P award.

As showed in **Figure 1**, the number of 3P projects increased each of the first four years since the introduction of Six Sigma in 3M Brazil, while the financial savings of 3P projects recently improved from an average of US$ 0.9 (in years 2002 to 2004) to US$ 3.8 millions (in 2005).

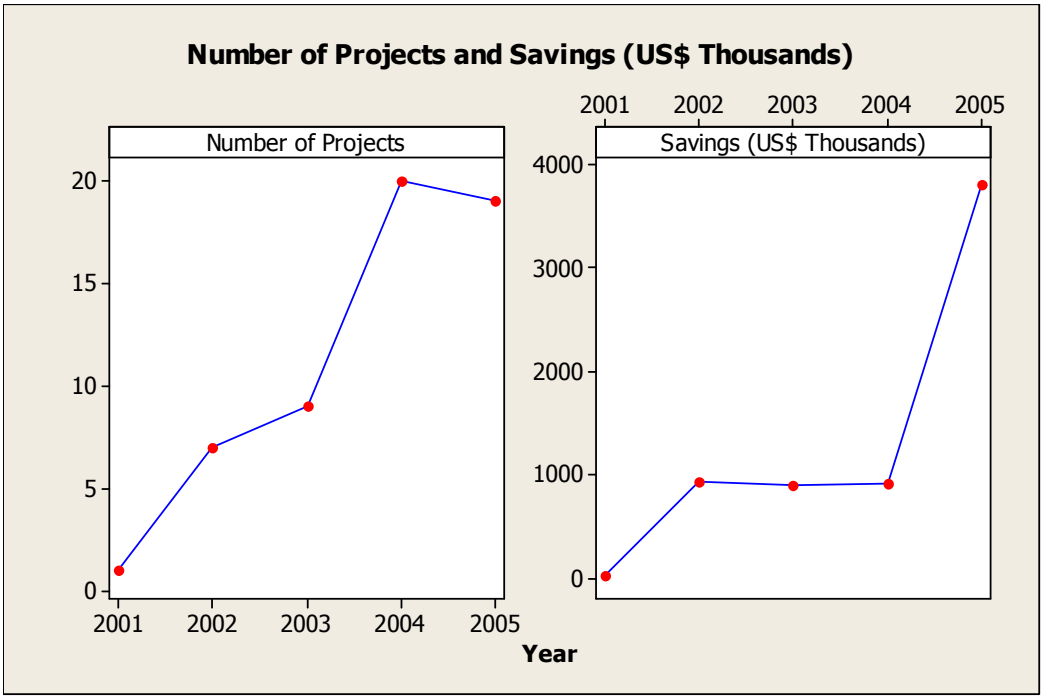

Figure 1: Number of projects and savings of the 3P program in Brazil

The Brazilian facilities were able to obtain important environmental achievements as the ISO 14000 certification before 2001, but were having obstacles to obtain recognized 3P projects before this date. Different from operations in US, the Brazilian operations are more complex due to the larger spectrum of products they produce. In fact, since the Brazilian market is significantly smaller than the US market, Brazilian plants must be designed for

more product variety, in order to maintain reasonable productivity and return on investment. However, in plants for high variety, it is difficult to control data on wastes and emissions, which poses barriers for participating in the 3P Program.

Therefore, it is not surprising that the subsidiary improved its ability to recognize 3P projects after the institution of the Six Sigma methodology after 2001. In fact, Six Sigma utilizes a set of quality and statistical tools, in order to collect reliable data for project management.

In Brazil, 3P projects from 2001 to 2005 were focus on:

a. Solid waste reduction for re-usage in the productive system;

b. Energy productivity improvement;

c. And the elimination of solvent usage, by substituting it for water based adhesives.

The abrasives division presents an interesting case for raw material reutilization. The project recycled both materials from its own production process, as materials from final industrial clients operations.

The protective masks division also reutilized fibers, which were mixed to new fibers and returned as raw materials into the productive process.

A different project category is for energy consumption reduction, in which a project team changed the manufacturing process and the organizational structure, for reducing pollutants emission in 26% and energy consumption in 25%.

In order to reduce toxic emissions, another 3P project improved the paper treatment method, which changed to a solventless water based process, resulting in 61 tons air pollution prevented.

In the financial perspective, the Pollution Prevention Pays program in Brazil is described in **Figure 2**. From the total of the financial gains in four years of the 3P program, only 2% of this amount was necessary as investments for the 3P projects. In the other hand, the financial gains were originated form the cost reduction, improvements in the operational productivity, energy reduction, reduction of materials sent to landfills and also from sales increase, by creating a new product size for decreasing material wastes.

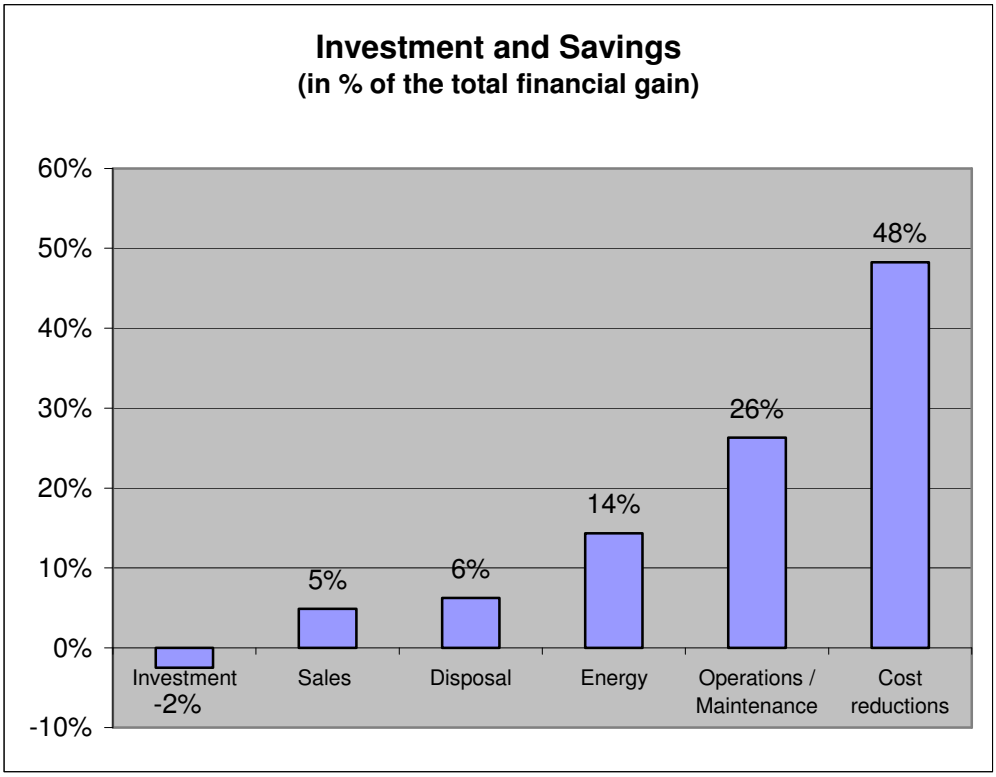

Figure 2: Investments and financial gains of the 3P program from 2001 to 2004 (CALIA, 2006).

6. Interviews with 3P Project Leaders

Ten project leaders were interviewed, in order to understand how the Six Sigma methodology helped to manage projects for improving the environmental performance.

The following Six Sigma quality tools were most utilized by the 3P project leaders interviewed:

a) The FMEA (Failure Mode and Analysis Effect) for identifying the project changes risks and for identifying the waste causes;

b) The Multi-variables Analysis, in order to statistically validate the waste causes;

c) And the DOE Design of Experiments for conducting experiments with statistical validity and for achieving optimized process parameters with minimized wastes.

The interviewed project leaders claim that the main benefits from the Six Sigma methodology are the better prospecting of project opportunities, the more effective approach to optimize processes, the more reliable method to obtain valid data and the means to conclude projects faster.

Firstly, Six Sigma methodology helped project leaders to identify new project opportunities. In fact, the ambitious Six Sigma goals provide pressure to motivate the project teams to systematically search for new opportunities of waste reduction.

Once the project opportunities were defined, the Six Sigma methodology helped project teams to more deeply understand the determinants of the manufacturing process, in order to identify optimized parameters, for example, to substantially increase the recycled materials usage percentage for a certain product.

Moreover, the Six Sigma project teams work with two different goals: the official project goal and the extended goal representing the best possible performance for the process under scope. This extended goal challenges the project team to really search for optimized process parameters for waste minimization.

The Pollution Prevention Pays program requires measurable data to demonstrate that pollution was prevented. In this sense, the Six Sigma methodology is a contribution, because it utilizes the MSA – Measurement System Analysis – for quantifying how reliable the project data are, by means of audits or of repeatability and reproducibility analysis.

Finally, 3P project leaders stated that without the Six Sigma methodology their project would have longer cycle times, because they would rely on the "trial and error" method. In the other hand, the leader of a 3P project, who did not utilized the Six Sigma methodology claimed that his project would be concluded much faster, if he would have utilized the Six Sigma tools.

7. Future Perspectives

For the Pollution Prevention Pays program creator, Dr. Joseph Ling, the environmental challenge in the new millennium requires a next development step from pollution prevention toward sustainable development and environmental design (LING, 1997).

The sustainable development concept implies in utilizing the minimum resources, in order to produce the maximum benefits for human society, without damaging the ability of future generations to meet their own needs. In the other hand, the environmental design concept focuses on developing products and processes, which cause none or little environmental damage.

Moreover, Dr. Ling believes that these next steps for sustainable development and environmental design require the collective work of business leaders, communities and government.

This paper provides evidences that Dr. Ling's 3P program may stimulate valuable insights for those responsible to conduct companies toward sustainability. For this change process, Dr. Joseph Ling shares valuable principles from his own experience: "Environmental issues are emotional. Environmental decisions are political. Environmental solutions are technical. No technical solution to a pollution problem can be accepted if it is not presented in harmony with the emotional and political realities." (SORENSON, 1999).

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