

Quality Costs and Hidden Quality Costs: Their Importance and Their Environmental Association

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Abstract

Quality Costing and Environmental Costing are closely related issues. For many years, the Prevention Appraisal Failure approach is employed for the measurement of the Quality Costs. Recently, this approach has been widened and includes some new categories that are called the Hidden Quality Costs. This category includes the Manufacturing Loss and the Design Loss. The former is the cost of using the production equipment at lower efficiency rate than the nominal one. The Design loss is the costs incurred because of ill design or the money spent in order to achieve more than required product quality. The Hidden Costs are big even if compared with the Prevention Appraisal Failure Costs and they represent huge opportunities for cost reduction. Also, the Environmental Costs have been classified according to the Prevention Appraisal Failure model. In this paper, the Environmental Cost classification is extended to the Hidden Cost category. Quality Costs and Environmental Costs of a Japanese company have been measured and presented in this paper. The company produces posters, catalogues, labels, foils and similar products. Many times Hidden Costs could play the role of the carpet that other costs are hidden. For example, a company in order to reduce its waste - that is a Failure Cost - decreases the speed of the production machines. Although, the Failure Cost is reduced, the Hidden Cost is increasing because the equipment does not operate at its most efficient rate. A final fact we should underline is that the Prevention and Appraisal Costs could be further categorized in Costs and Losses. So, Quality Costs are important and if we take into account the Hidden Quality Costs their importance becomes bigger. As it is certain that environmental pressure will increase in the coming years, Environmental Costing can provide the organizations with the necessary information in order to cope with this pressure. The identification of the Hidden Environmental Costs will not only put these organizations one step beyond the expected level of pressure but also their reduction will contribute to increased production eco-efficiency, they will be having less impact to the environment to produce a better and cheaper product.

1. Introduction

Some decades ago, when the importance of quality realized, it was considered that in order to achieve high quality, excessive waste and failures were unavoidable. From that point of view, quality management and environmental management were not compatible concepts. As quality management evolved, a new perspective emerged; the economics of quality. The economics of quality or as it better known quality costing is the measurement and endeavor to decrease quality related costs. As quality related cost today is defined "the cost in ensuring and assuring quality as well as loss incurred when quality is not achieved". [1]

Also, environmental issues are business issues. They are closely related to the quality issues and can have considerable implications in an organization's performance. Business related environmental issues usually attract the public attention only when there is a major accident. In such cases the liable company pays huge amounts of money in penalties and suffers an image destruction that is difficult - if not impossible - to quantify. In September 1999, there was a nuclear accident in Tokaimura, 140 km (90 miles) northeast of Tokyo. It is more than certain that the company will

have to pay huge penalties and compensations additionally to the negative publicity it suffered. The plant is operated by the Tokyo-based JCO Co, a subsidiary of Sumitomo Metal Mining co. Although such major incidents may have severe implications in a company, there are other cases that usually pass undetected - at least by the vast majority of the public - but can result in considerable amounts of money in losses or savings, depending on the case. These costs that pass more or less undetected are costs that are considered unavoidable. For example, waste or the inefficient use of the production equipment are such costs that as it will be shown later are considerable ones.

2. Literature Review

In Quality Costing saying Prevention, Appraisal and Failure we mean: As Prevention Quality Cost all costs that occur in order to prevent failures. Typical examples of Prevention Quality Costs are personnel training on quality issues and quality planning. As Appraisal Quality Cost the cost of activities to reveal shortfalls as soon as possible after they occur. Examples of Appraisal Quality Costs are inspection and quality audits. As Failure Quality Cost the cost of the production of any unacceptable product. Scrap, lost energy and pollution can be mentioned as typical examples of Internal Failure, while cost of disposing, warranties, cost of recall and loss of sales are typical examples of External Failure Costs. Furthermore, recently some new quality cost categories have been identified and their perspectives could be applied to the Environmental Costs as well. There are two categories of Hidden Quality Costs; the Manufacturing Loss and the Design Loss. Saying Environmental Manufacturing Loss, we mean the cost of the environmental impact due to the decrease of the production equipment in order to reduce failures. For example, when a company uses its equipment at 100% of its nominal speed there are 2% failures, if the speed is reduced to 80% of its nominal speed the failures drop to 1% and if the speed is reduced to 60% the failures are almost zero. According to the Prevention Appraisal Failure model the failure rate decline is a cost reduction. But the Prevention Appraisal Failure fails to address the fact this decline was not a result of an improvement activity but it was the result of inefficient use of the available resources. This cost is very often result of pressure put on quick reduction of the failures; but reducing the failures in such way it is not real improvement, it like hiding the costs under the carpet. Typical examples of Environmental Manufacturing Loss is time spent for set-up and adjustment, speed down loss, equipment failure and energy loss. The cost of the Environmental Manufacturing Loss can be surprisingly high. The other Hidden Cost is the Design Loss. Saying Design Loss we mean the costs incurred because of ill design or the money spent in order to achieve more than required product quality. Typical examples of Design Loss are nonconformance to the specifications set by the customer and excessive quality that the customer will not experience.

Environmental Costs arise from the fact that environmental pressure is applied on an organization to have the least possible impact on the environment. A company, in order cope with this pressure, must take measures to comply with these demands. Environmental pressure comes from legislation, corporate customers, public concern, and environmental groups to name some of them. No company can ignore the above mentioned pressures. In order to control their Environmental Costs, companies first must identify them. Hughes and Willis [2] classified the Environmental Costs in categories that are used for the classification of the quality-related costs. As it was mentioned before, Quality Costs are classified in Prevention, Appraisal and Failure Costs, a classification that is attributed to the seminal paper of Feigenbaum [3]. Although Hughes and Willis classified Environmental Costs according to the above-mentioned classification, they did not provide any data that would support their proposal.

In this paper, we will show the importance of the Quality Costs, of the Hidden Quality Costs. Also the concept of the Hidden Cost will be extended and we will show that these Hidden Environmental Costs are vast. Data from a Japanese company will be presented as a proof of this argument.

Although the complementary nature of quality management and environmental management is not something new, there are still parts that could be integrated. Elkington *et al* [4] said that the integration of environmental management into the quality management should lead to a unified environmental quality management. Houldin [5] described environmental management as an element of a Total Quality Management strategy that should be called Environmental Quality Management. Also, the Eco-Labeling Regulation [6], that is active in EU since 1993, takes a Life Cycle Assessment approach to products. The Life Cycle Assessment identifies a product's impacts on the environment during

its life from cradles-to-grave [7]. An additional related development is the issue of the BS7750 [8] standard on environmental management systems by the British Standards Institution. It would be worth to mention Gore's [9] approach that described the way the company 3M deals with environmental problems; it employs a "pollution prevention pays" policy that is a "win-win" situation. The Environmental Protection Agency [10] (of the U.S.) mention the term hidden costs in a classification that divides the costs in four categories; the usual costs, the hidden costs, the liability costs and the less tangible costs and benefits. Russel *et al* [11] described the environmental cost accounting as the bottom line for the Environmental Quality Management. Also, Itoh [12] should be mentioned for summarizing the environmental aspects of the Quality Costs.

Gray and Collison [13] classified the business posture versus the environment in three main categories. The business that consider greening as a passing fad, the ones that environmental issues are significant but not critical and the ones that consider natural environment to be in crisis. A typical business of the first category would do nothing for its environmental impacts, a company from the second category would just follow the laws and the public opinion, and a company from the third category will aim for sustainable business. Gray *et al* [14] identified some third category companies that include ICIC, BAT and Dow Chemicals, but it is IBM that leads the way and applies the highest standards worldwide, usually much higher than the local ones. The point is that these companies not only save money because they aim towards environmentally sustainable business but also they are very successful and profitable. The situation could be likened with the quality costing perceptions some decades ago. Then the general perception was that failure was unavoidable. It was till Crosby [15] that said "Quality is free" that much more attention was paid to Appraisal and Prevention measures. As companies that invested in Appraisal and Prevention in order to reduce quality costs saved huge amounts of money, we believe that companies that set high standards for the environmental issues will be successful too. From that point of view, as quality cost categories have been expanded and this expansion proved fruitful, so the environmental cost categories should be expanded further. Quality Costs are costs that the company eventually pays. In line with this point of view, we will try to expand the Environmental Cost concept as the costs that the company actually pays due to its environmental impact.

2. Classification of Environmental Costs according to the Quality Cost Classification and the Environmental Hidden Costs

As we mentioned before Hughes and Willis [2] allocated the environmental costs according to the Prevention Appraisal Failure classification. After we explain briefly this classification, the identification of the Hidden Environmental Costs that corresponds to the Hidden Quality Costs will be described extensively. In Quality Costing saying Prevention, we mean the activities that occur to prevent failures, Appraisal is the activities to reveal shortfalls after they occur and failure is the cost of nonconformance to the requirements. Similarly, in environmental costing there can be the Prevention, Appraisal and Failure categories. Environmental Prevention Cost is the cost for any improvement that contributes to reduced impact to the environment or contributes to prevent the failures to occur. Examples of Prevention activities are the activities taken for compliance with the state regulations or other standards like ISO 14000, environmental planning, training and improvements that reduce the organization's impact to the environment. Environmental Appraisal Cost is the money spent for activities that will reveal shortfalls after they occur. Examples of appraisal activities are inspections either internal or external, the cost of measuring the environmental impact of the company to the environment and environmental audits. Finally, Environmental Failure is the cost of, the cost of the byproducts and the cost to handle them when the process runs according to the specified requirements. It can be further divided in external and internal failure. In the former, it involves third parties; in the later it does not. For example, scrap is an internal failure; noise pollution that affects the neighborhood is external failure.

Besides the above-described costs there are other Environmental Hidden Costs. There are two categories of Environmental Hidden Costs; the Environmental Manufacturing Loss and the Environmental Design Loss. Saying Environmental Manufacturing Loss, we mean the cost of the environmental impact that is the total of the cost of any unacceptable product, the cost of the byproducts and the cost to handle them when the production process is out of the specified requirements. The Environmental Hidden Costs occur unexpectedly and if the incident that causes them is not

controlled properly at an early stage their consequences can be severe. As with the Environmental Failure, the Environmental Hidden Cost can be further derived in Internal and External Hidden Cost. A defect product that has not been delivered to the customer is an Internal Environmental Hidden Cost and a defect product that has been delivered to the customer is an External Environmental Hidden Cost.

The other Hidden cost is the Environmental Design Loss. Saying Environmental Design Loss we mean the costs the company must burden due to the environmental impact that derive from ill design or the money spent in order to achieve more than required product quality. Typical examples of Design Loss are nonconformance to the specifications set by the customer and excessive quality that the customer will not experience. Design Loss has a unique characteristic; the first is that its causes root at the early stages of a products life, its consequences are long term and cumulative. Any amendment requires further expenses for the correction of the design and additionally the set-up of the production line. This cost could be associated with the concept of Design for Environment. Design for the Environment is an emerging business practice which takes a life-cycle approach to new products and process development, taking into account such novel concerns as environmental consequences, human health and safety. [16]

We could define as Environmental Cost as the money that a company pays in order to ensure and assure that it does not have any environmental impact plus the cost of not achieving the target of production with no-environmental impact. The above-described classification of the environmental costs as well as the classification of the respective quality costs is summarized in **Table 1**:

Table 1 Environmental and Quality Costs

Costs	Categories	Environmental cost examples	Quality cost examples
Prevention Cost	Standard Compliance	ISO 14000 compliance	ISO 9000 compliance
	Improvement cost	Process improvement (reduced environmental impact)	Process improvement (reduced production cost)
		Used material environmental impact reduction	Used material environmental impact reduction
		Improvement of recycling process	Improvement of recycling process
Appraisal Cost	Internal inspection	Environmental monitoring system	Quality monitoring system
	External audit	Environmental audit fees	Quality audit fees
Failure Cost	Internal failure	Money for disposal of waste (paper, ink, etc)	Money for disposal of waste (paper, ink, etc)
	External failure	Environmental claims – penalties	Quality claims – penalties
		Adjustments – Improvements to meet environmental regulations	Adjustments – Improvements to meet quality standards
Manufacturing Loss	Wasted resources	Wasted resources to produce defect products	Wasted resources to produce defect products
	Material loss	Excessive material	Excessive material
	Energy loss	Excessive energy	Excessive energy
	Speed down loss	Reduced speed to meet the failure target	Reduced speed to meet the failure target
Design Cost	Design's environmental impact	Reduced Environmental Impact through Design	Excessive quality

4. Company Data

For confidentiality reasons, we will name the company that the data were gathered as company K. It was found in 1946 in Osaka, Japan. Company K is a printing company that prints posters, catalogues, labels, foils and similar products. The company's headquarters are in Osaka, but there are factories (totally 5) both in Osaka and in Tokyo. Each factory is specialized in a particular printing technique. The company's main customer is a leading brewery and beverage producer in Japan and well known overseas. The company's sales for the fiscal year 1997/98 were 11.6 billion yen, while the number of employees is around 400.

It is worth to mention that Company K introduced a Total Productive Maintenance program in 1989. The implementation of the program was very successful, and three years later the company won the TPM Excellence Award - Second Category by the Japan Institute for Plant Maintenance. The company continued its efforts and in 1998 applied and received the prestigious TPM Excellence Award - First Category. These continuous efforts yielded and the company has reduced significantly its quality costs. The company can be considered to have reached a mature level as it concerns the quality costs, as failure losses are smaller than the appraisal and prevention costs/losses. These data are shown in Table 2.

Table 2 Quality Costs and Hidden Quality Costs

Cost	Examples	Amount in million Japanese Yen
Prevention Cost	Planned Maintenance	69.33
	Preventive Maintenance	
Appraisal Cost	Inspection Waiting time	32.52
	Material trouble	
Failure Cost	Internal	11.53
	External	
Manufacturing Loss	Set-up & adjustment loss	374.93
	Speed down loss	
	Equipment failure loss	
	Machine out of production chain	
Design Cost	Delay due to ill design	6.40

The costs concern the fiscal year 1999. The amounts are in Japanese yen. The Environmental Prevention cost was 125 million-yen. The major costs are the improvement of the plate-making system that cost 94,700,000 yen, the paper scattering prevention that cost 15,000,000 yen, the improvement in the air-conditioning system that cost 4,600,000 yen, the installation of the organic solvent recovery equipment that cost 3,500,000 yen.

The Environmental Appraisal cost was 23 million-yen. The major costs are for the investigation of the processed water environmental effect that cost 9,143,000 yen, the internal inspection personnel cost that is 3,427,000 and the environmental guidance that cost 2,400,000 yen.

The Environmental Internal Failure cost was 36 million-yen. The blank form waste disposal and processing cost 10,377,000 yen, the paper evaporation cost 7,401,000 yen, the production waste is 4,190,000 yen, the ink waste disposal and processing cost 2,600,000 yen.

The Environmental External Failure costs were 156 million-yen. Usually the external failure costs are not so big but the concerned year there was a major cost in order the company to meet the legal requirements. The cost for the noise reduction of the air-conditioning system was 120,000,000 yen. Also, a damage to the air-conditioning system caused by the waste cost 26,000,000 yen.

Table 3 Environmental Costs and Hidden Environmental Costs

Cost	Examples – Major costs	Amount in million Japanese Yen
Prevention Cost	Plate making system	125
	Parer scattering prevention system	
Appraisal Cost	Investigation of the processed water	23
	Internal inspection	
Internal Failure Cost	Blank form waste disposal	36
	Paper evaporation	
External Failure Cost	Air-condition noise reduction	156
Hidden Cost	Defect product	360

The Environmental Hidden Costs were the largest of all costs their total amount was 360 million-yen. The major cost was the defect product and its cost is 343,004,000 yen. Also, there are quality-related costs and speed down loss that their total is 17.000.000 yen.

The above data can be summarized in **Table 3**.

5. Discussion

The first comment we could make about environmental costs is that they are considerable. No company can ignore them and if do so it may profit in the short run but this will be a very short-sight policy as it is more than certain that it will face difficulties in the future. The Environmental Costs at the concerned company amount the total of 700 million yen, that is 6% of the company's sales. The next comment we could make is that the Hidden Environmental Costs are the major environmental cost. It is 51% of the total Environmental Costs. The allocation of the Environmental Costs is shown in **Figure 1**.

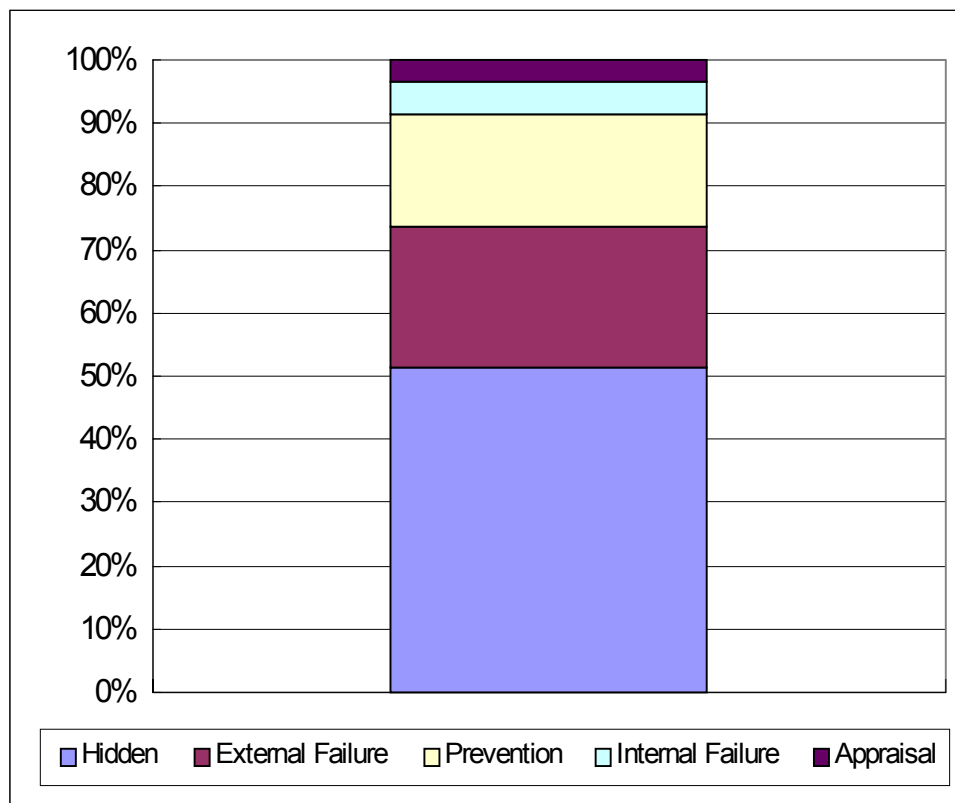


Figure 1: Allocation of the Environmental Costs

The Prevention Appraisal Failure Quality costs follow the pattern shown in **Figure 2**. At first the Failure Costs are high and the Prevention and Appraisal Costs just a small fraction of the overall costs. As the company starts to deal with quality costs the Prevention and Appraisal Costs raise and the Failure Costs fall. Finally, after the company has embedded a quality cost conscious culture the Prevention and Appraisal Costs fall and the overall Quality Costs converge to the minimum. The similarities between the Quality costs and the Environmental Costs make us to believe that Environmental Costs as well follow the same pattern. As with the Quality Costs, at first the Failure Costs are high and the Prevention and Appraisal Costs are low. Then as the company decides to deal with the Environmental Costs, at first the Appraisal and then the Prevention Costs rise and consequently the Failure costs drop. At this point the company may notice an increase of the Internal Failures against the External Failures, though the sum of the two will continue to drop. After the initial impressive results, the Failure Costs will continue to get reduced but with a smaller rate. At this

point the Appraisal and the Prevention Costs will start to decrease and will converge to a minimum.

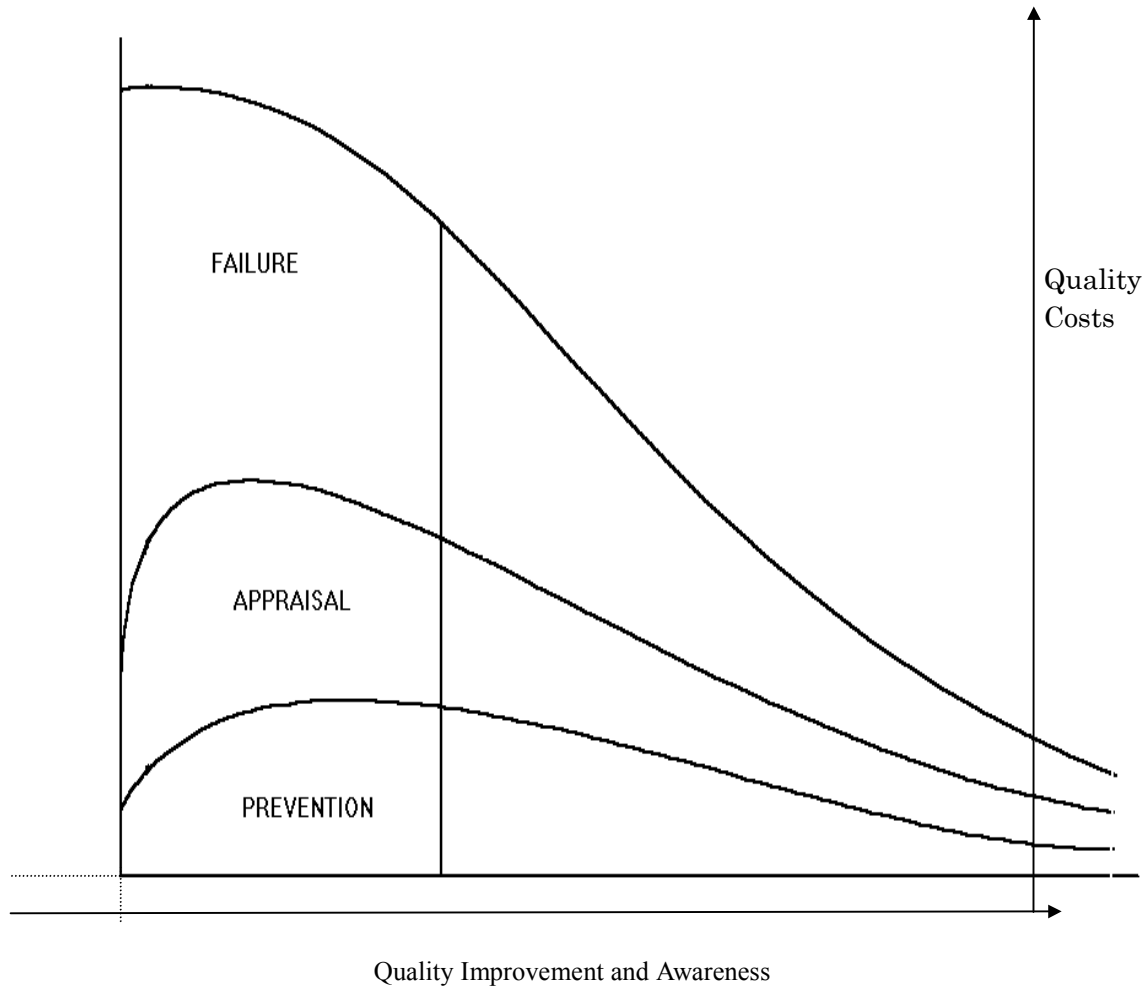


Figure 2: Allocation of the Quality Costs in the Company according to BS 6143 Part 2 [1]

Another point that attention should be paid is that sometimes Hidden Costs could play the role of the carpet that other costs are hidden. For example, a company in order to reduce its waste - that is a Failure Cost - decreases the speed of the production machines. Although, the Failure Cost is reduced, the Hidden Cost is increasing because the equipment does not operate at its most efficient rate. The environmental impacts are increased energy consumption, and additional pollution. So, there was not improvement as it could be reported if we had measured only the Prevention, Appraisal Failure Costs but just transfer of the costs from one category to another.

A final fact we should underline is that the Prevention and Appraisal Costs could be further categorized in Costs and Losses. The former are successful Prevention or Appraisal measures while the later are unsuccessful Prevention or Appraisal measures. While the Prevention and Appraisal Costs as we defined them above create and add value, the Prevention and Appraisal Losses destroy and reduce value. A Prevention or Appraisal unsuccessful action - that is a loss - besides of the cost of the action itself, can have further consequences. For example, the measurement of the pollution that a factory makes is an Appraisal action. If the measurement is wrong, all further actions will be based in false data. So, the Appraisal Loss is not only restricted to the cost of the measurement but it includes all the money that will be wasted because of this loss. Similarly a Prevention Loss is not only the money for the unsuccessful action but for all the money spent for actions that derived from it and had no result.

6. Conclusions

Environmental pressure is high and it is generally believed that will be higher in the future. The companies should not see the pressure increase as a threat but as a change for improved efficiency. In this paper, we showed the importance of the Quality Costs and the Hidden Quality Costs. Then we showed the association between Quality and Environmental Costs. Finally we extended the Prevention Appraisal Failure concept of the Environmental Costs and we proposed the category of Hidden Environmental Costs. The Hidden Environmental cost category includes the Manufacturing loss and the Design loss. The former is the cost of using the production equipment at lower efficiency rate than nominal one. The Design loss is the costs incurred because of ill design or the money spent in order to achieve more than required product quality. The Hidden costs are big even if compared with the Prevention Appraisal Failure costs. We measured the hidden costs in a company and it was found out that these costs are considerable and are potential opportunities for improvement.

References

- [1] British Standards Institute, BS 6143: Guide to the Economics of Quality, Part 2. Prevention, Appraisal, Failure Model, London, BSI (1990)
- [2] Hughes S. B., Willis D. M., How Quality Control Concepts Can Reduce Environmental Expenditures, Cost Management, Summer 1995, pp15-19, 1995.
- [3] Feighenbaum, A.V. Total Quality Control, Harvard Business Review, 34, pp. 93-101, 1956
- [4] Elkington, J., Knight, P and Hailes, J. The Green Business Guide, Golancz, London, 1991.
- [5] Houldin M. "TQM and environmental management" Integrated Environmental Management, No. 9 May 1992, (pp. 5-7), 1992.
- [6] Hillary, R., The eco-labelling regulation, BSi news, October, pp.12-13. 1993.
- [7] Wenzel, H., Hauschild, M., Alting, L., Environmental Assessment of Products, Chapman & Hall, London, 1997.
- [8] British Standards Institution, BS 7750:1994, Specification for environmental management systems, 1994.
- [9] Gore, A., Earth in Balance: Ecology and the Human Spirit, Penguin, 1994.
- [10] Environmental Protection Agency, Pollution Prevention Benefits Manual, U.S. Environment Protection Agency, 1989.
- [11] Russel, W.G., Skalak S.L. & Miller, G., "Environmental Cost Accounting: The Bottom Line for Environmental Quality Management", Total Quality Environmental Management, Spring, pp. 255-268, 1994.
- [12] Itoh, Quality Cost Management (in Japanese: Hinshitsu Cosuto Manejimento) Chuo Keizaishya, 1998.
- [13] Gray, R. H., Collison D. J., Environmental Audit: Green gauge or Whitewash? Managerial Auditing 6(5) (pp. 17-25), 1991
- [14] Gray, R., Bebbington J., Walters, D., "Accounting for the Environment", Markus Wiener Ltd, Princeton 1994
- [15] Crosby, P.B. Quality is Free, New York, McGraw-Hill, 1979.
- [16] Fiksel, J., Design for Environment: Creating Eco-Efficient Products and Processes, McGraw – Hill, New York, 1995.