Industrial Engineering and Operations Research
NATIONAL POLLUTION PREVENTION CENTER FOR HIGHER EDUCATION

For the Instructor: Teaching Note on "Total Quality Management: A Methodology for Pollution Prevention"

Purpose

This exercise is designed for inclusion in an introductory Total Quality Management course. The material requires between 50 and 80 minutes of class time for discussion of the articles and case study. The reading material should be assigned to students prior to class. There are in-class discussion points as well as homework questions.

While designed for industrial engineering students, the material is appropriate for other engineering students and business school students (both undergraduate and graduate levels). Students should have a familiarity with the concepts of customer focus, continuous improvement, teamwork, and strong management commitment prior to the class.

Answers

1. Students should mention some of the following:
   - Customer focus calls for reduction of waste.
   - Root-cause analysis prevents waste rather than controls it.
   - "Zero waste" is analogous to "zero defects."
   - Deming's principles call for elimination of waste.
   - Continuous improvement of process waste also identifies quality issues.
   - Team approach encourages different perspectives on the problem.
2. Potential answers include:
   - Plant workers
   - People downstream from plant who use the river for drinking water
   - Fish downstream from plant
   - Birds dependent on fish for food
   - Fishermen
   - Farmers who use river water for irrigation
   - Children playing near dump (land or water)
   - Asthmatics downwind from plan
   - Homeowners near the plant who want to sell their houses
   - Nearby residents who are allergic to pollutants (air or water)
3. It doesn't get to the root of the problem. It controls existing waste rather than finding ways to prevent it. It is reactive to regulation rather than proactive. Also, environmental engineers are not familiar enough with the processes to suggest improvements.
4. The team approach allows more factors of the environmental issue to be considered, because more staff are contributing specialized knowledge of the various processes that affect those issues.

National Pollution Prevention Center for Higher Education • University of Michigan
Dana Building, 430 East University, Ann Arbor MI 48109-1115
Phone: 313.764.1412 • Fax: 313.936.2195 • E-mail: nppc@umich.edu

5. Some answers are:

   - Results of customer focus groups' requesting "environmentally friendly" products
   - Publicity of competitors' economic success with TQEM
   - Legislation requiring pollution prevention
   - Inclusion of environmental quality criteria, such as those required by the Malcolm Baldridge Award, ISO-9000, and Ford Q-1.

The matrix at the end of this compendium's Resource List indicates 20 books and articles on TQM and industrial engineering.

Further information on quality awards can be obtained from the following organizations:

Malcolm Baldridge National Quality Award
A537 Administration Building
National Institute of Standards and Technology
Gaithersburg, MD 20899-0001
301/975-2036

ISO 9000
CEEM Information Services
10521 Braddock Road
Fairfax, VA 22032
800/745-5565

Ford Q-1
Ford Motor Quality Publications
c/o EDCOR Data Services
P.O. Box 9079
Farmington Hills, MI 48333-9079
810/626-3077

Original produced on Hammermill Unity DP,
a 50% post-consumer/50% pre-consumer recycled paper
made from de-inked old newspapers and magazines.

Published by:
The National Pollution Prevention Center for Higher Education
University of Michigan, Dana Building
430 East University Ave.
Ann Arbor, MI 48109-1115
• Phone: 313-764-1412
• Fax: 313-647-5841
• E-mail: nppc@umich.edu

The mission of the NPPC is to promote sustainable development by educating students, faculty, and professionals about pollution prevention; create educational materials; provide tools and strategies for addressing relevant environmental problems; and establish a national network of pollution prevention educators. In addition to developing educational materials and conducting research, the NPPC also offers an internship program, professional education and training, and conferences.

Your Input is Welcome!
We are very interested in your feedback on these materials. Please take a moment to offer your comments and communicate them to us. Also contact us if you wish to receive a documents list, order any of our materials, collaborate on or review NPPC resources, or be listed in our *Directory of Pollution Prevention in Higher Education.*

We're Going Online!
The NPPC provides information on its programs and educational materials through the Internet's Worldwide Web; our URL is: **http://www.snre.umich.edu/~nppcpub/** (click on "National Pollution Prevention Center").

We may also update the NPPC information available through gopher (gopher.snre.umich.edu) and anonymous FTP (ftp.snre.umich.edu). Please contact us if you have comments about our online resources or suggestions for publicizing our educational materials through the Internet. Thank you!

Industrial Engineering and Operations Research
NATIONAL POLLUTION PREVENTION CENTER FOR HIGHER EDUCATION

Total Quality Management: A Methodology for Pollution Prevention

Prepared by Leith Harmon, NPPC Research Assistant, under the supervision of Katta Murty, Professor of Industrial and Operations Engineering, University of Michigan.

Introduction

As a result of global competition, consumers demand better product and service quality. At the same time, some consumers' environmental concerns continue to grow. Total Quality Management (TQM), a system that can help companies achieve high product and service quality, has inherent strengths that effectively address some environmental issues.

Professionals who apply TQM concepts to environmental issues have coined the term Total Quality Environmental Management (TQEM). This is a logical method for producing the results of another concept gaining speed in industry: pollution prevention. This paper explains how the concepts of TQEM can be employed to successfully prevent pollution.

Background

In *Total Quality Control*, Armand Feigenbaum defines product and service quality as:

> [T]he total composite product and service characteristics of marketing, engineering, manufacture, and maintenance through which the product and service in use will meet the expectations of the customer.[1]

To achieve product and service quality many organizations employ TQM. Its management elements include:

- Customer focus
- Continuous improvement
- Teamwork
- Strong management commitment

Yet, who is the customer, and how can TQM principles be applied to environmental concerns?

CUSTOMER FOCUS

In the context of quality, the customer is defined as the person who "employs the product and service characteristics."[2] Customers fall into two categories. The *internal* customer is the next person in the production chain; the *external* customer is the end-user of the product. For instance, in the auto industry, the person who installs the bumper is an internal customer to the department producing the bumpers; the external customer is the purchase of the finished car.

If the definition of the customer is expanded to include the people and environments effected by production process *waste*, TQM requires us to understand how this waste affects those customers and take steps to reduce it. Both W. Edwards Deming and Kiyoshi Suzaki, legends in the field of TQM, have defined waste as "that which does not add value."[3] For this paper, we define waste more specifically: the physical by-products of a process. This can be excess paper in an insurance office as well as waste chemicals from a paper mill. When we more narrowly define waste, the principles of its elimination put forth by Deming and Suzaki are no less pertinent.

As an example, many industries use the solvent trichloroethylene (TCE) in their operations. This highly toxic chemical must be contained in a closed system, as releases of TCE can be fatal. Such releases often require the evacuation of the entire facility. Here the plant workers are the unwilling internal customers of TCE fumes. The external environment is also an unwilling customer. Rivers downstream can be affected by the effluent of a paper mill or oil refinery. Aquatic life in the river and people dependent on the river for drinking water are unwilling customers of this effluent.

Continuous Improvement

Those who have embraced TQM understand that quality can only be *built* into the product, not *inspected* into. This requires the producer to continuously identify and eliminate the root causes of impediments to quality. Continuous improvement is also the key to reducing the environmental impacts of the production process.

The traditional approach to industrial waste has been to view it as a necessary, though unwanted, by-product of manufacturing. While production generates the waste, the responsibility to dispose of the waste in a safe and legal manner usually falls on the environmental engineering department. Because environmental engineers receive the waste after it has been created, they are not intimately familiar with the processes that create it. Further, because waste reduction is not a component of their performance reviews, they do not have the institutional motivation to reduce the waste.

The environmental engineering department is also responsible for completing government forms documenting the facility's wastes. Government regulations are created to ensure the health of plant workers, the surrounding community, and the environment in general. However, these regulations often create requirements that are very cumbersome and expensive for industry. For instance, under the Superfund law, a Toxic Release Inventory (TRI) must be completed each year. The TRI process, which records the volumes of waste generated by a facility, requires paperwork that can take up to three months to complete; like product quality inspection, this is certainly not value-added! Replacing toxic materials used in the manufacturing process with more environmentally benign materials reduces the paperwork.

TQEM is the logical method for preventing pollution wherever possible. Employing a customer focus and classifying the waste itself and the activities required to control it as non-value-added, TQEM calls for waste generation to be brought to a minimum.[4] Operators and process engineers, not environmental engineers, are responsible for identifying and eliminating the root causes of process waste. Employing the continuous improvement approach, "zero waste" is as important a goal as "zero defects."

As a result of TQEM projects, product quality often improves while waste is reduced. One possible explanation might be that TQEM efforts empower employees to become more familiar with all aspects of the process, not those just associated with production. When employees are forced to consider process wastes, improvements to quality characteristics can result.

Teamwork

The team approach allows all factors of the environmental issue to be considered. Accountants are familiar with cost considerations, product engineers are familiar quality considerations, process and chemical engineers are familiar with feasibility considerations, and environmental engineers are familiar with environmental impacts. Because environmental engineers are trained to deal with waste *after* it has been generated, and not in methods of preventing it from being created in the first place, engineers with knowledge of the process characteristics must be involved.

For example, degreasing certain aluminum components with TCE has required extensive safety mechanisms and procedures. Building better containment systems reduces the risk of exposure, but does not get to the root cause of the problem — the use of TCE. With this in mind, Ford, an active TQEM proponent, looked for a TCE-free solution to degreasing radiator coils.[5] Ford formed a team that included a chemical engineer, an environmental engineer, a process engineer, an accountant, and a product engineer. The variety of backgrounds on the team ensured that the pertinent issues of cost, product quality, process feasibility and environmental impact were all addressed. The Ford team designed an aqueous degreasing system (i.e., soap and water) to replace the TCE. Not only does the plant avoid using this toxic chemical, but the water in the new system is recycled as well. Significantly, the aqueous degreaser exhibits better quality characteristics than the TCE degreaser.

The above project is an example of the best of all worlds: improved quality, reduced cost, and reduced environmental impact. Certainly not all projects will prove so fruitful. Some "clean" alternatives may cost more than their polluting rivals, but that cost must be balanced with the benefits of the environmental improvement.[6] To justify this viewpoint, one needs only to look to the increasing expectations of external customers for "environmentally friendly" products.

Strong Management Commitment

It should now be clear that three of the elements of TQM — customer focus, continuous improvement, team approach — readily apply to environmental issues. As in traditional TQM settings, the last — strong management commitment — is perhaps the most important. No TQEM program will succeed without the commitment of senior management. Senior management, those who have built their careers when waste was seen as a necessary by-product, must come to understand that both internal and external customer expectations include environmentally conscious products and processes. They must learn to see the value of applying TQEM to get to the root causes of waste, and call on the cross-disciplinary teams to employ continuous improvement to implement ever "cleaner" solutions.

Conclusion

In the manufacturing setting today, the focus on environmental issues mirrors the focus on quality issues in the 1980s. As environmental regulations get stricter and more costly, as consumers demand more environmentally conscious products, and as competitors begin to see economic benefits from reducing waste, industrial management will employ TQEM as it employed TQM throughout the 1980s. The technology and the innovative spirit of employees exists; it must now be focused on the root cause of process waste to reap the rewards.

ENDNOTES

[1] Armand V. Feigenbaum. *Total Quality Control.* New York: McGraw-Hill, 1991, p 7.

[2] ibid.

[3] W. Edwards Deming. *Out of the Crisis.* Cambridge, MA: MIT, 1986, p. 92.

Kiyoshi Suzaki. *The New Manufacturing Challenge.* New York: The Free Press, 1987, p. 8.

[4] It is worth noting that some process waste (such as some wastewater) is relatively benign to the environment. The principles of TQEM should be focused on those waste streams that pose the highest risk to environmental and human health.

[5] President's Commission on Environmental Quality, Quality Environmental Management Subcommittee. *Total Quality Management: A Framework for Pollution Prevention.* Washington, 1993.

[6] Current accounting systems often neglect to apply the costs of toxic waste removal and potential liability and fines (under ever-tightening regulations) directly to the process department. These costs are generally grouped together for the whole facility. When these costs factored in, the "clean" solution often appears more attractive.

Questions

1. Relate how TQM principles apply so well to environmental issues.
2. Name three environmental customers that might be affected by a facility's waste.
3. Why is the traditional approach to industrial waste handling insufficient?
4. Why is it necessary to use the team approach when attacking waste issues?
5. What are some ways to make senior management more aware of the benefits of TQEM?

Original produced on Hammermill Unity DP,
a 50% post-consumer/50% pre-consumer recycled paper
made from de-inked old newspapers and magazines.

The National Pollution Prevention Center for Higher Education
University of Michigan, Dana Building
430 East University Ave.
Ann Arbor, MI 48109-1115
• Phone: 313-764-1412
• Fax: 313-647-5841
• E-mail: nppc@umich.edu

The mission of the NPPC is to promote sustainable development by educating students, faculty, and professionals about pollution prevention; create educational materials; provide tools and strategies for addressing relevant environmental problems; and establish a national network of pollution prevention educators. In addition to developing educational materialsand conducting research, the NPPC also offers an internship program, professional education and training, and conferences.

Your Input is Welcome!
We are very interested in your feedback on these materials. Please take a moment to offer your comments and communicate them to us. Also contact us if you wish to receive a documents list, order any of our materials, collaborate on or review NPPC resources, or be listed in our *Directory of Pollution Prevention in Higher Education.*

We're Going Online!
The NPPC provides information on its programs and educational materials through the Internet's Worldwide Web; our URL is:
http://www.snre.umich.edu/~nppcpub/
Please contact us if you have comments about our online resources or suggestions for publicizing our educational materials through the Internet. Thank you!