



Pollution Prevention: A Logical Role for the Industrial Engineer

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Introduction

Industrial engineers do not generally concern themselves with pollution, but with the production process. Historically, that has meant minimizing cost and maximizing throughput and quality. The waste generated in these processes has been taken as a given, to be dealt with by environmental engineers.

However, as Stephan Schmidheiny of the Business Council for Sustainable Development describes the environmental crisis, it is everyone's concern:

Several global trends demand any thinking person's attention First, the human population is growing extremely rapidly Second, the last few decades have witnessed an accelerated consumption of natural resources Third, both population growth and the wasteful consumption of resources play a role in the degradation of many parts of the environment Fourth, as ecosystems are degraded, the biological diversity and genetic resources they contain are lost Fifth, this overuse and misuse of resources is accompanied by the pollution of atmosphere, water and soil — often with substances that persist for long periods.¹

Currently as well as historically, industry has dealt with pollution by using increasingly more sophisticated and expensive methods of control and treatment. In light of the issues Schmidheiny raises, the use of these technologies adds an ever-increasing, non-value-added component to product cost. A more proactive approach is demanded: pollution must be prevented, not just controlled after the fact.

The more pollution is prevented from ever being produced, the less money has to be spent controlling it. The prevention/control issue arises in other settings outside of process waste. For instance, antibiotics *control* illnesses; vaccines *prevent* them. Similarly, inspection *controls* defects; design for quality *prevents* defects.

Therefore, the question arises: What role can and should the industrial engineer play in pollution prevention? Because industrial engineers (along with chemical and mechanical engineers) are responsible for the production process, they should have a role in managing its undesired outputs (waste) as well as its desired outputs (product). Environmental engineers should be called on in instances when wastes cannot be prevented at their source by process engineers.

Why Pollution Prevention?

In the past, governmental regulations have emphasized pollution control. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, or "Superfund") and the Superfund Amendments and Reauthorization Act (SARA) oversee the resolution of past toxic waste disposal activities that have adversely impacted the environment. The Resource Conservation and Recovery Act (RCRA) regulates current disposal activities. The U. S. Environmental Protection Agency (EPA) is authorized to fine parties that do not follow the stipulations of these acts. Not only are companies legally bound to dispose of their waste pursuant with these laws, but they are also required to produce extensive documentation of the wastes they generate, which is both time-consuming and expensive.

One way pollution prevention saves companies money is through decreased regulatory compliance and waste treatment costs. It can also position them more competitively for future regulation. In 1990, Congress passed the Pollution Prevention Act, which established a national policy that "pollution should be prevented or reduced at the source whenever feasible."² Unlike the acts discussed above, the Pollution Prevention Act is not enforceable. However, as of 1993, 15 states had issued mandatory, enforceable regulations on pollution prevention³; others will likely follow. Other countries already have enforceable policies in place. In Germany, for example, companies are required to collect and recycle all packaging of their product; they are thus forced to develop innovative methods of reducing unnecessary packaging.⁴ Whether or not a similar law is passed in the United States, farsighted companies will see pollution prevention as a proactive and cost-effective method of dealing with waste in the future.

Pollution prevention also allows a company to minimize the future waste-disposal liability. Under Superfund, businesses can be held liable for the future cleanup costs of contaminated sites, *even if the company followed the waste disposal procedures put forth by regulations at the time of disposal*. Thus, preventing pollution reduces costs a firm can expect to pay in the future.

Government isn't the only group calling for pollution prevention: consumers as well are demanding that manufacturers produce products sensitive to the environment. All things being equal, Ford Motor Company's market research shows that consumers are more likely to buy a product manufactured by the company that is perceived as "green." Roper Starch Worldwide annual surveys show that

as the public's environmental knowledge grows, so will the cost of being perceived as a polluter McDonald's is a [good] case in point. In the 1980s, the company had a negative environmental image associated with its use of polystyrene packaging. Now it has become one of the leading proponents of recycling and consumer education, and it is the top-rated company in the U.S. in terms of its environmental reputation among consumers.⁵

Principles of Pollution Prevention for the Industrial Engineer

While pollution prevention focuses on the reward of a cleaner environment, the benefits to a company's bottom line should not be overlooked. L. P. Sullivan states that quality-focused actions and expenditures are:

strongly centered in the problem-solving arena, with less attention to the other end of the spectrum: product development To move to the same position as the Japanese . . . the quality issue must be pushed farther and farther upstream.⁶

This paradigm can also be used to illustrate pollution's impacts on and costs to the production process. The Taguchi loss function and the Taguchi methods have shown that engineers who initially perform to specification and subsequently design products and processes for quality can reduce the costs of production. The same concepts apply equally well to preventing pollution. Focus on waste treatment should be replaced by efforts to continuously improve current manufacturing processes to minimize waste. As these projects reach a mature state, focus should in turn be placed on designing products and processes that prevent waste in the first place. (See **Figure 1**)

In current practice, products and processes are generally designed without regard to waste. The responsibility for dealing with waste falls to the environmental engineer, who must handle these process by-products after they are produced. This is similar to designing a product merely for function, concerned more with short-term cost and throughput than with quality and long-term cost (per Taguchi's Loss Function), and relying on inspection to root out defective products.

For example, for the majority of companies painting auto bodies, the process utilizes solvents containing toluene and xylene. These toxic chemicals comprise the majority of airborne pollutants released to the environment by auto companies. Sophisticated smoke stack scrubbers send solvents skyward. Per Sullivan's paradigm, using scrubbers qualifies as treatment.

In following Sullivan's model, businesses should first begin to address pollution at the manufacturing process level. While treatment focuses on handling waste after the fact, waste reduction is a proactive approach: taking an existing process and minimizing the waste it produces by making small mechanical and chemical process changes.

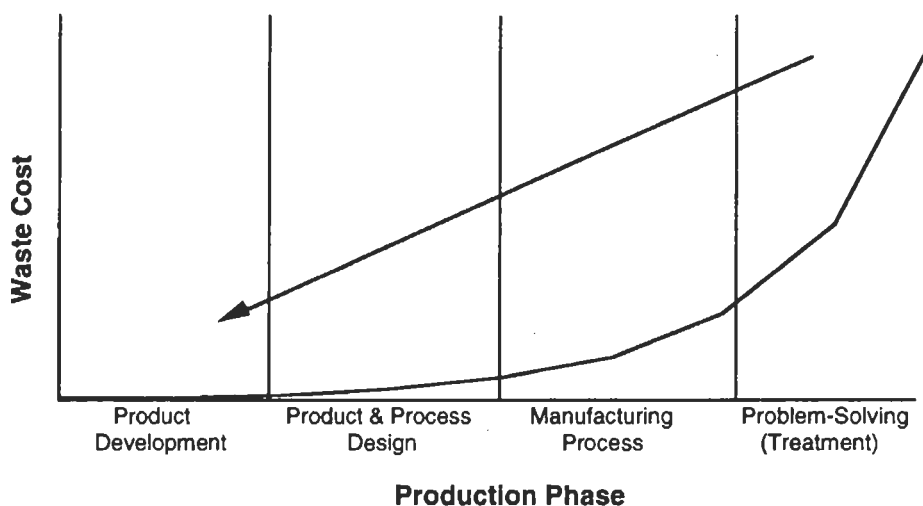


FIGURE 1: POTENTIAL FOR POLLUTION PREVENTION

Some forward-thinking companies (such as 3M, Dow, Ford, S. C. Johnson & Sons, Polaroid, and IBM) have begun to study their current manufacturing processes in an effort to reduce the waste they generate. While Toyota has made continuous process improvement famous in an effort to reduce defects, 3M and Dow have used the idea of continuous improvement in an effort to reduce process waste. Through a formalized program, "Pollution Prevention Pays," 3M has been able to halve its pollution between 1975 and 1989. Dow's program, "Waste Reduction Always Pays" (WRAP), has resulted in a 21% reduction in overall releases reported under SARA between 1987 and 1989.

In the paint shop example, it is common for American auto companies to change paint color with each car that goes through the process. As a result, any paint remaining in the previous lines must be purged before painting each car; in addition, the purging and refilling setup activity adds time to the process. When auto manufacturers change from this process to "block painting" (sending like-colored cars through the paint line in batches), they reduce purged paint sludge and the fugitive solvent emissions of toluene and xylene. Further, block painting decreases the setup time involved in the process.

Whether addressing quality or waste, continuous improvement can only go so far in improving a process that has already been designed. Once all marginal gains are realized in the current process, attention needs to be directed to designing processes that prevent waste from ever being created.

Continuing the paint shop example, technology now exists to paint cars without the toxic toluene and xylene solvents. Similar to the way a photocopier affixes ink to paper, electrostatic painting can adhere paint to treated metal. While the scrubber represents treatment and block painting represents waste reduction, shifting to the electrostatic painting process represents pollution prevention by design. According to data from Toyota, the electrostatic technology exists, and actually exhibits better quality characteristics than solvent-based painting. Unfortunately, paint booths represent a large capital investment (upwards of \$10 million) that is usually amortized over a decade. Because the Big Three automakers have all invested in new solvent-based paint booths within the past five years, electrostatic painting will not become commonplace in the U.S. for another five to ten years.

The IE/OR Pollution Prevention Educational Resource Compendium

It should now be obvious that industrial engineers, along with their chemical and mechanical engineering colleagues, must play a role in developing industrial processes that prevent pollution. To adequately train future engineers, curricula must be developed, catalogued, and disseminated to industrial engineering faculty. The accompanying "Pollution Prevention and IE/OR Resource List" addresses this need by taking inventory of the pollution prevention educational resources available in the field. To assist readers in focusing on their field of specialty, these materials are

organized by industrial engineering subtopics: Decision Analysis, Facilities Planning, Operations Research, Production Control, Total Quality Management, Capital Budgeting, and Organizational Design/Management of Change. Existing educational material includes books, journal articles, case studies, and syllabi. Other materials in this compendium include articles, case studies with teaching notes, and problem sets.

Conclusion

The goal of pollution prevention in the design process is an ideal toward which all companies should strive. Given the present state of American industry, however, significant gains can still be achieved in altering current manufacturing processes. And, as long as this is the case, industrial engineers will play a crucial role in the successful implementation of pollution prevention.

ENDNOTES

- ¹Stephan Schmidheiny. *Changing Course*. Cambridge, MA: MIT Press, 1992.
- ²Pollution Prevention Act of 1990, 42 Pub. L. No. 101-508, §§6601-6610, 104 Stat. 1388.
- ³A list of current state pollution prevention laws is available in the NPPC's Business Law Compendium, in "Business Law and Pollution Prevention Resource List."
- ⁴Joanna D. Underwood and Bette Fishbein. "Making Wasteful Packaging Extinct." *The New York Times* (April 4, 1993): sec. 3, p. F13.
- ⁵Peter Stisser. "A DEEPER Shade of Green." *American Demographics* (March 1994): 26, 28.
- ⁶L.P. Sullivan. "The Seven Stages of Company-wide Quality Control." *Quality Progress*, (May 1986): 39-50.

Discussion Points

Why should a company look to pollution prevention?

Historically, industry has dealt with pollution using increasingly more sophisticated and expensive methods of control. The use of these technologies adds an ever increasing non value-added component to a product's cost. A more proactive approach is demanded when addressing this issue. Pollution must be prevented, not just controlled after the fact. With pollution prevention, there will be less pollution to control, resulting in lowered costs.

Companies are legally bound to dispose of their waste properly. Further, they are also required to produce time consuming documentation of the wastes they generate. Far sighted companies will see pollution prevention as a proactive and cost-effective method of dealing with waste in the future.

What are other examples of the prevention/control issue?

The prevention/control issue arises in other settings outside of pollution prevention. For instance, vaccines *prevent* illnesses, while antibiotics *control* illnesses. Preventative car maintenance *prevents* wear, while replacing worn parts deals with the problem after the fact. Design for quality *prevents* defects, while inspection *controls* defects.

What is the industrial engineer's role in P2?

Because the industrial engineer (along with chemical and mechanical engineers) is responsible for the production process, he/she should be responsible for managing the undesired outputs (waste) of the production process as well as the desired output (product). The environmental engineer should be called on to treat only those wastes that cannot be prevented by process engineers.

What are examples of pollution treatment and control?

- smoke stack scrubbers
- waste water treatment
- landfill disposal

What are some examples of existing manufacturing process change to reduce pollution?

- block painting
- recycling rinse water
- recycling washer chemicals
- recycling office paper
- reusable containers

What are some examples of process design to prevent pollution?

- electrostatic painting
- packaging redesign
- "paperless" office automation

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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/> Please contact us if you have comments about our online resources or suggestions for publicizing our educational materials through the Internet. Thank you!