Technology's Impact on the Environment: Both Problem and Solution

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Increased levels of environmental awareness and concern are making businesses set and adhere to higher standards of environmentally-responsible operation and remediation than ever before. AT&T's responsibility is considerable because, with 32 manufacturing locations around the world that produce about $12 billion in manufactured products, the company's operations have the potential to make a large environmental footprint. AT&T has aggressively targeted eliminating ozone depleting chlorofluorocarbons (CFCs), reducing the use of other toxic or polluting substances, and also decreasing waste generated by manufacturing operations. This report on environmental technology documents some of the technical work underway both in the environmental R&D organizations at AT&T Bell Laboratories, and in manufacturing facilities, to help us achieve these goals.

Introduction

Environmental technology must keep pace with industrial technology if society is to continue enjoying the fruits of technological innovations. We have entered a period of unprecedented awareness of and concern for threats to the environment. In the past, for example, if a forest was cut down for lumber or firewood, or if a dam was built to provide power or a reliable source of drinking water, the effect of such projects was limited, usually to an area within a radius of perhaps a few miles. Today, however, we recognize that environmental insults in one place can affect people hundreds or even thousands of miles away. The effects are global, and include ozone depletion, global warming, acid rain, diminished air quality, loss of animal and plant species, and saturation of the usual sinks—such as our atmosphere, waterways, and landfills—for the wastes generated by civilization.

Because of growing awareness and concern, the environment is a critical issue among peoples, countries, and companies around the world. Thus, the world's businesses are being held by government and public opinion to a higher standard of operation and remediation than ever before. And the technological capabilities that make industry a major contributor to environmental problems at the same time offer opportunities for solutions.

AT&T shares this responsibility, for it has 32 manufacturing locations worldwide that produce about $12 billion in manufactured products. Therefore, its operations have potentially serious environmental effects. Fortunately, AT&T brings both technical skills and a strong environmental commitment to this responsibility. It has set environmental goals for its manufacturing operations, and has committed to eliminating chlorofluorocarbon (CFC) use, reducing toxic emissions, and decreasing the amount of manufacturing waste it produces as a byproduct of its operations. These goals go beyond simply complying with existing or expected laws or regulations: they are long-term, "stretch" goals. That is, they have been set as a spur to continuous improvement in years to come. They are not a public relations gimmick, but a management technique to raise awareness inside the company, and provide focus for technological development.

This issue of the *AT&T Technical Journal* deals with environmental technology. It documents some of AT&T's work—both in our environmental R&D organizations at AT&T Bell Laboratories and in our manufacturing facilities—to help us achieve these goals. The environmental commitment and technical expertise of our people will become apparent from the papers in this issue.

Panel 1. Acronyms Used in This Paper

CFC	chlorofluorocarbon
EPA	Environmental Protection Agency
ICOLP	Industry Cooperative for Ozone Layer Protection
TQM	Total Quality Management

AT&T's Goals for Manufacturing Operations

Early in 1990, AT&T announced aggressive, company-wide "stretch" goals to phase out chlorofluorocarbon emissions, eliminate toxic air emissions, and decrease the production of manufacturing process waste requiring subsequent disposal.

Chlorofluorocarbon Phaseout Goal. CFCs are widely used in the electronics industry as degreasing and defluxing solvents. They are also used in air conditioners and refrigerators, and as a blowing agent to produce insulating and cushioning plastic foams. CFCs have gained wide acceptance because they are low in toxicity, non-flammable, non-explosive, non-corrosive, almost odorless, non-irritating, fast evaporating, efficient, and effective in many critical applications. Unfortunately, however, they have been implicated as a primary agent in destroying stratospheric ozone, a loss that could lead to reduced productivity of phytoplankton—the base of our food chain—and increased incidences of skin cancer, cataracts, and diseases caused by impaired human immune systems.

In response to this danger, an international agreement, the Montreal Protocol, requires the complete phaseout of CFC production by the year 2000. This agreement also calls for phasing out methyl chloroform (1,1,1-trichloroethane) and carbon tetrachloride, which also have been implicated in stratospheric ozone destruction.

AT&T, using its 1986 emissions figures as the baseline, took a leadership role in CFC elimination by pledging to reduce CFC emissions from manufacturing operations 50 percent by year-end 1991, and to eliminating them completely by the end of 1994. We are proud to report that we reached the 50 percent elimination goal in 1990, a year ahead of schedule.

Toxic Air Emissions Elimination Goal. In addition to CFCs, other solvents are used to manufacture electronic equipment. These solvents include methylene chloride, methyl chloroform, trichloroethylene, tetrachloroethylene, acetone, and methyl ethyl ketone. When emitted into the atmosphere, these chemicals may, under certain conditions, contribute to forming smog and tropospheric ozone, an air pollutant with serious health effects.

AT&T's goal was to reduce toxic air emissions—as defined by and reportable under the Environmental Protection Agency (EPA) Superfund Amendments and Reauthorization Act, Section 313—50 percent by the end of 1991, 95 percent by the end of 1995, and to strive for 100 percent by the end of 2000. The company used emissions in 1987 as its baseline. Again, we are proud to report that our toxic air emissions were reduced 58 percent by the end of 1990, a full 8 percent and one year ahead of our stated goal.

Manufacturing Process Waste Goal. As industry, technology, and society have advanced, so has their solid waste generation. Raw materials and disposal sites for wastes were once thought to be in limitless supply. But with the discovery of environmental contamination from many of these disposal sites, and the realization that natural resources *can* be depleted, the environmental movement has gathered worldwide strength. The costs associated with raw material purchase and waste handling, disposal, and site remediation have been skyrocketing.

The environmental and economic effects of waste generation have caused companies, including AT&T, to look for ways to reduce the amount of waste being sent to disposal facilities. To address its part of the problem, AT&T has set a goal to reduce the amount of manufacturing process waste to be disposed by 25 percent by the end of 1994. This will be accomplished by redesigning processes and products to minimize the amount of waste initially generated, and to reuse or recycle the wastes that remain. The program will have the additional benefit of reducing the demand for raw materials. AT&T locations have implemented many programs to make significant progress toward meeting this goal.

Total Quality Management

AT&T's continued success in exceeding its environmental goals is based on clearly defined objectives and applied quality principles and tools to help achieve them. Moreover, AT&T's top management has committed itself to the Total Quality Management (TQM) approach, consisting of policy deployment, quality in daily work, and quality improvement teams. By deploying planning processes that are responsive upward and downward in the organization, AT&T's long term goals have been linked to the corporate groups, business units, and individual process owners

at the company's facilities. The focus in policy deployment is on process improvement planning, and goals are continually being reached and exceeded as our processes improve. The TQM approach has allowed our employees to choose the technology solutions that work for them. Overcoming the barriers between our goals and performance has been achieved by using gap analyses and action plans assigned to individuals. The process requires continuous communications with successive layers of management on the actions required to close the gaps and meet the corporate goals.

Sharing of Technology

AT&T was a founding member of the Industry Cooperative for Ozone Layer Protection (ICOLP). This organization was created in December 1989 to assist technology transfer from the developed to the developing countries so they may avoid installing CFC based processes. There are over 2 billion people in China and India alone, many of whom look forward to their first refrigerator or air conditioner, and to other technologies traditionally dependent on CFCs. If we do not assist them in installing environmentally benign technology, they could completely negate the progress that has been made by developed countries in phasing out CFCs and other harmful chemicals.

In This Issue

The papers in this issue describe some of the technical programs and processes we have used to address AT&T's environmental goals.

An environmental success story by E. Sherwood, L. DiMarino, and P. Joseph describes how the AT&T Printed Circuit Board Headquarters at Richmond eliminated many chemical solvents used to manufacture printed circuit boards. Their paper describes the total factory approach to finding alternative, non-solvent-based process options.

The paper by J. R. Piazza et al. looks at the end-to-end flow of materials through a factory, creates a waste minimization factory model, and identifies opportunities for waste minimization based on analyses performed.

The paper by C. L. Fraust et al. covers several areas related to integrated circuit manufacturing and the initiatives taken to reduce dependency on various chemicals through substitution or better process control.

The need to monitor the various emissions and effluents from the factory in real time provides the capability to control processes that might emit environmentally harmful materials. The paper by L. S. Bernson et al. describes developing and applying monitoring systems within AT&T, and the associated data acquisition and analysis capability.

Low residue soldering fluxes that allow no-clean soldering in wave and reflow operations are described by L. Guth and J. R. Morris. These fluxes have eliminated the need for cleaning with CFCs and other halogenated substances.

Defluxing, degreasing, and other operations traditionally have relied heavily on halogenated solvents. G. Wenger et al. describe developing and implementing aqueous and semiaqueous alternatives, including terpenes (BIOACT® EC-7™), to produce major reductions in solvent use. (BIOACT and EC-7 are trademarks of Petroferm Inc.)

R. Brunner presents work using nitrogen dioxide (NO_2) doped plasma to clean hybrid integrated circuits as a replacement for CFCs.

Summary

AT&T has been involved in a broad range of activities to reduce the environmental effects associated with manufacturing electronic equipment. These activities have allowed us to establish and achieve ambitious "stretch" environmental goals for work in our factories and throughout the corporation. It is no accident that AT&T factories from Singapore and Bangkok, across the North American continent, and in Madrid, are either now, or are about to be, CFC-free.

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