SECTION 35
QUALITY AND SOCIETY

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THE BACKGROUND

Human society has depended on quality since the dawn of history. In primitive societies this dependence is on the quality of natural goods and "services." Human life can exist only within rather narrow limits of climatic temperature, air quality, food quality, and so on. For most primitive societies, life even within these narrow limits is marginal, and human beings in most primitive societies live precariously. Hours of work are often long and exhausting. Life spans are shortened by malnutrition, disease, natural disasters, and so on. To reduce such risks primitive societies created nonnatural aids to their mental and physical capabilities, aids such as:

- Division of labor.
- Community forms of society, such as villages.
- Artificial shelter, e.g., houses.
- Processing of natural materials to produce nonnatural goods such as pottery, textiles, tools, weapons.
- Lessons learned. The experience of the past—when to plant crops, which berries are poisonous—is handed down from generation to generation.

The subsequent growth of commerce and of science and technology greatly expanded the extent and variety of nonnatural goods and services. As a result human beings in many modern

industrial societies live longer and safer lives. They are largely shielded from the perils which their ancestors faced. However, all those nonnatural goods and services have created a new dependence, and therefore new risks.

Life behind the Quality Dikes. Years ago the author coined the phrase "life behind the quality dikes" to designate these new risks (Juran 1969). In industrial societies, great masses of human beings place their safety, health, and even their daily well-being behind numerous protective "dikes" of quality control. For example, the daily safety and health of the citizenry now depend absolutely on the quality of manufactured products: drugs, food, aircraft, automobiles, elevators, tunnels, bridges, and so on. In addition, the very continuity of our life style is built around the continuity of numerous vital services: power, transport, communication, water, waste removal, and many others. A major power failure paralyzes the lives of millions.

There are numerous minor breaks in the quality dikes—occasional failures of goods and services. These are annoying as well as costly. Far more serious are the terrifying major breaks such as Chernobyl, Bhopal, Three Mile Island.

Not only individuals but also nations and their economies live dangerously behind the dikes of quality control. National productivity relies on the quality of product and process design. National defense relies on the quality of complex weaponry. The growth of the national economy is keyed to the reliability of its systems for energy, communication, transport, and so on.

So while technology confers wonderful benefits on society, it also makes society dependent on the continuing performance and good behavior of technological goods and services. This is life behind the quality dikes—a form of securing benefits but living dangerously. Like the Dutch who have reclaimed much land from the sea, we secure benefits from technology. However we need good dikes—good quality—to protect us against the numerous service interruptions and occasional disasters. These same risks have also led to legislation which at the outset was bitterly opposed by industrial companies. Since then it has become clear that the public is serious about its concerns. What is encouraging is that users (whether individuals or nations) are willing to pay for good dikes.

The ability to cope with breaks in the quality dikes varies remarkably among users. Large organizations (industrial companies, governments) employ technologists or otherwise use their economic and political strengths to plan, control, and improve quality. In contrast, the individuals (consumers, the citizenry) find themselves pitted against forces which to them seem as mysterious and overpowering as natural forces seemed to their primitive ancestors.

Any one individual has only a very limited capacity to deal with these forces. However, these individuals are very numerous. Collectively their economic and political powers are formidable. These powers have emerged as a movement generally called *consumerism.* This movement, though loosely organized, has become influential in providing individual members of society with protection and recourse relative to breaks in the quality dikes.

THE GROWTH OF CONSUMERISM[1]

Consumerism is a popular name for the movement to help consumers solve their problems through collective action.

No one knows whether the *rate* of consumer grievances has grown over the centuries. However we know that the *volume* of grievances has grown to enormous numbers due to the growth in volume of goods and services. By the mid-twentieth century, consumer frustrations had reached levels which stimulated attacks on industrial companies for their alleged responsibility for consumers' problems. Then, when most companies failed to take appropriate action, the resulting vacuum attracted numerous contenders for leadership of a consumerism movement: government agencies, politicians, social reformers, consumer advocates, consumer associations, standardization organizations, independent test laboratories, and still others. A risk arose that a bargaining agent would emerge to intervene between industrial companies and their customers.

[1] *Note:* The text for this topic includes some extracts and paraphrases of material from Juran (1995, chap. 17).

Consumer Problems and Perceptions. Starting in the 1970s researchers began to identify the dominant consumer problems as well as the perceptions of the groups in interest: consumers, consumer organizations, government, business, insurance companies, and so on. Table 35.1 lists the major quality-oriented consumer problems as derived from one such study (Sentry 1976, p. 5).

Consumer expectations sometimes rise faster than the market rate of improvement (Sentry 1976, p. 30.) In addition, consumer perceptions can differ from the realities. For example, many consumers believed that quality of product was getting worse; that "products don't last as long as they used to." Yet the author's studies of specific product lines have almost always found that quality has kept improving.

Consumers are generally more negative than positive on the attitudes of business toward problems of consumers. They strongly favor competition as a means of ensuring higher quality, safer products, and better prices. They also feel that most advertising is misleading, and that much is seriously misleading (Sentry 1976, pp. 7, 8, 12).

During the 1970s, consumer perceptions of the job done by specific industries varied widely. The favorable perceptions included banks, department stores, small shopkeepers, telephone companies, supermarkets and food stores, and airlines. At the other end of the spectrum, consumers had poor perceptions of car manufacturers, the advertising industry, the oil industry, garages and auto mechanics, used car dealers (Sentry 1976, p. 13).

While consumer perceptions are sometimes in error, the perceptions are important in their own right. People act on their perceptions, so it is important to understand what are the perceptions of consumers. For additional findings on consumer perceptions, see the study sponsored by the American Society for Quality Control (ASQC 1980).

Consumers generally felt that there was much they could do to help themselves relative to quality. They felt that the necessary product information was available but that the information was not being used by consumers. They had similar views with respect to product safety. They generally felt that most products were safe if used properly; also that many product safety problems arose because of failure to read the instructions properly (Sentry 1976, pp. 9, 10).

Remedial Proposals. There are a number of these, amid much difference of opinion. The differences arise in part because of the impact on costs and prices (see below). In addition there are differences due to a contest for power. The various consumer organizations and government departments all feel that they should play larger roles, and that certain traditional powers of business should be restricted.

Ideally, the remedies should eliminate the causes of consumer problems at their source. The consumerism movement has been skeptical that such prevention will take place at the initiative of the industrial companies. Hence the main proposals have related to establishing ways to enable consumers to judge beforehand whether they are about to buy trouble.

Access to Information before Purchase. Consumers could make better buying decisions if they had access to information on competitive product test data, field performance, and so on. Many

TABLE 35.1 Major Consumer Quality-Oriented Problems

Poor quality of many products
Failure to live up to advertising claims
Poor quality of after-sales service and repairs
Misleading packaging or labeling
Futility of making complaints: nothing substantial will be done
Inadequate guarantees or warranties
Failure of companies to handle complaints properly
Too many dangerous products
The absence of reliable information about the different goods and services
Not knowing what to do when something goes wrong with a purchased product
The difficulty of choosing which of the competing products to buy

Source: Sentry (1976), p. 5.

industrial companies possess such information but will not disclose it—they regard it as proprietary. They do disclose selected portions, but mainly to aid in sale of the product. The risk of bias is obvious.

Consumers' needs for information extend also to after-sale service, response to complaints, and so on. Here again, the companies regard such information as proprietary.

The lack of information from industrial companies has created a vacuum which has attracted alternative sources of product information to help consumers judge which products to buy and which to avoid. One such source is test laboratories which are independent of the companies that make and sell the products.

Under this concept a competent laboratory makes an expert, independent evaluation of product quality so that consumers can obtain the unbiased information needed to make sound purchasing judgments. Adequate consumer test services require professionals and skilled technicians, well-equipped test laboratories, acquisition of products for test, and dissemination of the resulting information. Financing of all these needs is so severe a problem that the method of financing determines the organization form and the policies of the test service.

Product Testing: Consumer-Financed. In this form the test laboratory derives its income by publishing its test results, usually in a monthly journal plus an annual summary. Consumers are urged to subscribe to the journal on the ground that they will save money by acquiring the information needed to make better purchasing decisions. Advertisements of such test laboratories raise questions such as "Would you pay $100 for an appliance when independent tests show that a $75 appliance is just as good?"

In their operation, these consumer-financed test laboratories buy and test competitive products, evaluate their performance and failures, compare these evaluations with the product prices, and rate the products according to some scale of relative value. The ratings, test result summaries, descriptions of tests conducted, and so on, are published in the laboratory's journals. The industrial companies play no role in the testing and evaluation. In addition, the companies are not permitted to quote the ratings, test results, or other material published in the journals.

It is seen that the service offered to consumers consists of:

1. The laboratory's test results, which are mainly objective and unbiased.
2. Judgments of values which are subjective and carry a risk of bias, i.e., the stress of the advertising (showing the consumer that some lower-priced products are as good as higher-priced products) creates a bias against higher-priced products. More importantly, the judgments are not necessarily typical of consumers' judgments.

Despite the obvious problems of financing a test service out of numerous consumer subscriptions, there are many such services in existence in affluent and even in developing countries. In the United States, the most widely known source of such tests is Consumers Union. The test results are published in the journal *Consumer Reports.*

Product Testing: Government-Financed. Governments have long been involved in matters of product quality, originally to protect the safety and health of the citizenry, and later, the environment. For elaboration, see below, under Government Regulation of Quality.

The most recent extension has been in the area of consumer economics. Some of this has been stimulated by the consumerism movement. A byproduct has been the availability of some product test results and other quality-related information. This information is made available to the public, whether in published form, or on request.

Government-Subsidized Tests. In some countries, the government subsidizes test laboratories to test consumer products and to publish the results as an aid to consumers. The rationale is that there is a public need for this information, and that hence the costs should be borne by the public generally.

Mandated Government Certification. Under this concept, products are required by law to be independently approved for adequacy before they may be sold to the public. This concept is applied in many countries to consumer products for which human safety is critical (e.g., pharmaceuticals, foods). For other products, there has been a sharp division in practice. Generally, the market-based

economies have rejected mandated government certification for (noncritical) consumer products, and have relied on the forces of the competitive marketplace to achieve quality. In contrast, the planned economies, as exemplified by the former Soviet Union, went heavily into the setting of standards for consumer products and the use of government laboratories to enforce compliance to these standards (which had the force of law).

Product Testing: Company-Financed. In this form, industrial companies buy test services from independent test laboratories in order to secure the mark (certificate, seal, label) of the laboratory for their products. In some product categories it is unlawful to market the products without the mark of a qualified testing service. In other cases it is lawful, but the mark is needed for economic reasons—the insurance companies will demand extraordinarily high premiums or will not provide insurance at all.

An example of a sought-after mark is that of Underwriters Laboratories, Inc. (UL). Originally created by the National Board of Fire Underwriters to aid in fire prevention, UL (now independent) is involved in the general field of fire protection, burglary protection, hazardous chemicals, and still other matters of safety. Its activities include:

- Developing and publishing standards for materials, products, and systems.
- Testing manufacturers' products for compliance with these standards (or with other recognized standards).
- Awarding the UL mark to products which comply. This is known as "listing" the products.

Numerous other laboratories are similarly involved in safety matters, e.g., steam boilers and marine safety. Some of these laboratories have attained a status in their specialty which confers a virtual monopoly on performing the tests.

Another purpose of securing a mark from an independent test service is to help market the product. Companies vary in their views of the value of such "voluntary" marks. Strong companies tend to feel that their own brand or mark carries greater prestige than that of the test laboratory, and that the latter has value only for weak companies. The test services which offer this category of marks vary widely in their purpose and in their objectivity.

In some countries the voluntary mark is offered by the national standardization bodies, such as Japan Standards Association or the French AFNOR. The mark is awarded to products that meet their respective product standards. Companies that wish to use the JIS mark (Japan Industrial Standards) or the NF mark (Normale Francais) must submit their products for test and must pay for the tests. If the products qualify, the companies are granted the right to use the marks.

Data Banks on Business Practices. Many consumer grievances are traceable to company business practices, such as evasiveness in meeting the provisions of the guarantee. The Pareto principle applies—a comparative few companies are named in the bulk of the grievances. In this way, a data bank on company business practices can help to identify the vital few "bad guys" and aid in reducing their influence.

The organizations known as Better Business Bureaus (BBB) created one such data bank. A description of BBBs and what they do is given in the following quotation from *Consumer's Resource Handbook* (1980):

> BBBs are non-profit organizations sponsored by private businesses. There are 147 BBB locations across the U.S. today, sponsored by local and national business. While BBBs vary from place to place, most offer a variety of basic services. These include: general information on products or services, reliability reports, background information on local businesses and organizations, and records of companies' complaint handling performances. Depending on the policy of the individual BBB, it may or may not tell you the nature of the complaints registered against a business. BBBs accept written complaints, and will contact a firm on your behalf.

The BBB receives complaints from consumers (among others) on unethical business practices, and endeavors as an ombudsman (see below) to get these practices changed. When citizens call the BBB, they are able to learn whether the company under inquiry has a record of complaints lodged against it.

BBBs also are active in helping consumers and local business firms to settle consumer complaints. (See below).

Consumer Education. Beyond product tests and data banks on business practices, still other forms of before-purchase information are available to consumers. Some government departments publish information describing the merits (or lack of merits) of products and product features in general. However, the most often used source of product information is advice received from relatives and friends who have experience to share. Consumers regard such advice as reliable (Sentry 1976, p. 55).

The limiting factors in consumer use of the available independent data sources are the consumers themselves. Fewer than 10 percent of families in the United States subscribe to *Consumer Reports.* The lack of use of other helpful information (much of which is available free to consumers) may well have its origin in a school system that makes little provision to educate children in one of the major roles they will play as adults—the role of consumer.

Some observers explain "unwise" consumer behavior on grounds other than lack of education. They note that many consumers spend money on narcotic drugs, alcohol, or tobacco; kill themselves (and others) by driving too fast or in a drunken state; eat "junk" food; gamble their money away. It is understandable that some skeptics conclude that consumers who are gullible or stupid will learn only from their mistakes.

Consumer organizations are quite aware that "most consumers do not use the information available about different products in order to decide to buy one of them." (Sentry 1976, p. 10). However, consumer organizations never characterize consumers (their clientele) as being gullible or stupid. (*Consumer Reports* 1977).

The Standards Organizations. There are many of these. For example, in the United States, those of importance to consumers include:

- Leading manufacturers and merchants, whose standards exert wide influence on their suppliers and competitors
- Industry bodies such as the American Gas Association or the Association of Home Appliance Manufacturers
- Professional organizations such as the American Society for Testing and Materials
- Independent agencies such as Underwriters Laboratories, Inc.
- The American National Standards Institute (ANSI), which is a recognized clearinghouse for committees engaged in setting national standards and is the official publisher of the approved standards
- The National Institute of Standards and Technology, formerly the National Bureau of Standards, the government agency which establishes and maintains standards for metrology

Standards for Consumer Products. Awarding a mark presupposes the existence of some standard against which the product can be tested on an objective basis. Providing such standards for consumer products has not received the priorities given to standards for metrology, basic materials, and other technological and industrial needs. However, the consumerism movement has very likely stimulated the pace of developing these standards. Industry associations especially have been stimulated to undertake more of this type of activity.

A serious limitation on creating standards for consumer products is the pace of product obsolescence versus the time required to set standards. Usually, it takes years to evolve a standard due to the need for securing a consensus among the numerous parties in interest. For subject matter such as metrology or basic materials, the standards, once approved, can have a very long life. However, for consumer products the life is limited by the rate of obsolescence, and for many products the life of the standard is so short as to raise serious questions about the economics of doing it at all.

In some cases the obsolescence is traceable to the zeal of the marketers. For example, one measure of the quality of mechanical watches has been the number of jewels. Then some manufacturers began to include nonfunctional jewels to provide a basis for claiming higher quality. It became necessary to redefine the word "jewel."

A further problem in standards for consumer products is that the traditional emphasis of the standardization bodies has been on "time zero"—the condition of the product when tested prior to use. However, many products, especially the most costly, are intended to give service for years. Many consumer problems are traceable to field failures during service, yet most consumer product standards do not adequately address the "abilities"—reliability, maintainability, and so on. (See generally Juran 1970.)

Objectivity of Test Services. Unless the testing service is objective, consumers may be misled by the very organization on which they thought they could rely. The criteria for objectivity include:

- *Financial independence:* The income of the test service should have no influence on the test results. This independence is at its best when the income is derived from sources other than the company whose products are under test. Failing this, the payments by the company should be solely for the testing service and in no way contingent on the test results.

  One example of failure to meet this criterion is any test service which carries on the dual activities of (1) offering a mark based on product test and approval and (2) publishing a journal of general circulation in which companies that receive the mark are required to place advertisements. In such cases the risk of conflict of interest is very high, so consumers should be cautious about giving credence to such marks.
- *Organizational independence:* The personnel of the test service should not be subordinate to the companies whose products are undergoing test.
- *Technological capability:* This obvious need includes a qualified professional staff, adequate test equipment and competent management. Whether the managers should be the sole judges of such capabilities is open to question.

So important is the question of objectivity that in cases of government controls on quality it is usual to write into the statute the need for defining criteria for what constitutes a qualified test laboratory. The administrator of the act then becomes responsible for certifying laboratories against these criteria.

The Resulting Information. Consumer test services offer consumers a wide range of information. The principal forms include:

- Comparative data on competitive products for (1) price and (2) fitness for use, plus judgments of comparative values. In this form, the information is also a recommendation for action.
- Data on product conformance to the standards. In this form, consumers are thrown on their own to discover competitive prices and to make a judgment on comparative fitness for use. For many consumers, it is a burden to provide this added information.
- Evidence of product conformance to the standard (through the mark.) Here the consumer is largely asked to equate the standard with fitness for use and to use other means to discover competitive differences and competitive prices.

Information on conformance to standard is quite useful to industrial buyers, but less so to consumers. For consumers the optimal information consists of comparative data on fitness for use, plus comparative data on cost of usage.

Traditional test services do not provide adequate information as to certain important quality problems faced by consumers: products arrive in defective condition; products fail during use; response to consumer complaints is poor.

- *Products defective on arrival:* Test services typically conduct their tests on a small sample—one or a few units of product. These nevertheless enable the test service to judge whether the product

design can provide fitness for use. However, the sample is too small to provide information on how often units will be defective on arrival.

- *Products fail during use:* Traditionally, test services have evaluated consumer products at "time zero"—prior to use. For long-life products this is no longer good enough–there is need for information on field failure rates. Some test services now do conduct a degree of life testing, but the number of units tested is too small to predict field failure rates. There are some efforts to secure such information through questionnaires sent to consumers. An alternative source is to secure information from the repair shops.
- *Poor response to customer complaints:* Here the situation is at its worst. The test laboratory and its instruments are irrelevant, since the needed information relates to the competence, promptness, and integrity of the service organizations.

Remedies after Purchase. Consumers who encounter product quality problems during the warranty period have a choice of alternatives. They may be able to resolve the problem unaided; i.e., they study the product information and then apply their skills and ingenuity. More usually they must turn to one of the companies directly in interest: the merchant who sold them the product; the manufacturer who made the product. If none of these provides satisfaction, the consumers have still other alternatives for assistance (see below).

Warranties. Quality warranties are a major after-purchase aid to consumers. However, many consumers feel that warranties are not understandable. In addition, most feel that warranties are written mainly to protect manufacturers rather than consumers. Nevertheless, consumers are increasingly making the warranty an input to their buying decisions. This means also that warranties are increasingly important as marketing tools (Sentry 1976, pp. 14, 15).

By a wide margin, consumers complain to the merchant (store, dealer) rather than to the manufacturer. A third choice is to complain to the Better Business Bureau. (Sentry 1976, p. 15).

Better Business Bureaus (BBB). The following is quoted from *Consumer's Resource Handbook* (1980).

> BBBs attempt to settle consumer complaints against local business firms. A BBB considers a consumer complaint settled when:
>
> 1. The customer receives satisfaction.
> 2. The customer receives a reasonable adjustment—in other words, gets what was paid for.
> 3. The company provides proof that the customer's demands are unreasonable or unwarranted.
>
> The BBB does not: judge individual products or brands, handle complaints concerning the prices of goods or services, or give legal advice.
>
> More than 100 of the 147 BBBs offer binding arbitration to those who ask for it, and others are beginning programs. Arbitration is a way for people to settle a dispute by having an impartial person or board (people who have nothing to gain or lose from the decision) decide the outcome of the dispute. In arbitration, parties are bound by the decision, and it can be enforced by the courts. Do not enter arbitration lightly since you must follow the decision that is made.
>
> BBBs also handle false advertising cases. Your local BBB looks into local advertising, while the BBBs' National Advertising Division (NAD) checks out complaints about national advertising.
>
> How to Reach Them: To find a BBB, check your local phone book, local consumer office, or library.

The Ombudsman. Ombudsman is a Swedish word used to designate an official whose job is to receive citizens' complaints and to help them secure action from the government bureaucracy. The ombudsman is familiar with government organization channels and is able to find the government official who has the authority or the duty to act. The ombudsman has no authority to compel action, but has the power to publicize failures to act.

The concept of the ombudsman has been applied to problems in product quality. Some companies have created an in-house ombudsman and have publicized the name and telephone number. Consumers can phone (free of charge) to air grievances and to secure information. In the United States a more usual title is Manager (Director), Consumer Affairs (Relations). Such a manager usually carries added responsibilities for stimulating changes to improve relations with consumers on a broad basis. In one company these efforts resulted in programs to effectuate a consumer "bill of rights," which includes rights to safety, to be informed, to choose, to be heard, and to redress. For elaboration, see Peterson (1974).

Another form is the industry ombudsman. An example is the Major Appliance Consumer Action Panel (a group of independent consumer experts) created by the Association of Home Appliance Manufacturers to receive complaints from consumers who have not been able to secure satisfaction locally.

Still another form is the Joint Industry-Consumer Complaint Board. Examples are the government-funded boards which mediate and adjudicate consumer disputes in some Scandinavian industries. The boards have no power to enforce their awards other than through publicity given to unsatisfied awards. Yet they have met with wide acceptance by and cooperation from the business people.

The concept of the ombudsman is fundamentally sound. It is widely supported by consumers and regulators as well as by a strong minority of business managers (Sentry 1976, p. 77). Some newspapers provide an ombudsman service as part of their department of Letters to the Editor.

Mediation. Under the mediation concept, a third party—the mediator—helps the contestants to work out a settlement. The mediator lacks the power of enforcement—there is no binding agreement to abide by the opinion of the mediator. Nevertheless mediation stimulates settlements. Best (1981) reports that the New York City Department of Human Affairs achieved a 60 percent settlement rate during 1977 and 1978.

The mediation process helps to open up the channels of communication and thereby to clear up misunderstandings. In addition, an experienced mediator exerts a moderating influence which encourages a search for a solution.

Arbitration. Under arbitration the parties agree to be bound by the decision of a third party. Arbitration is an attractive form of resolving differences because it avoids the high costs and long delays inherent in most lawsuits. In the great majority of consumer claims, the cost of a lawsuit is far greater than the amount of the claim. Nevertheless there are obstacles to use of the arbitration process. Both parties must agree to binding arbitration. There is need to establish local, low-cost arbitration centers and to secure the services of volunteer arbitrators at nominal fees or no fees. These obstacles have limited the growth of use of arbitration for consumer complaints.

Consumer Organizations. There are many forms of consumer organizations. Some are focused on specific products or services such as automotive safety or truth in lending. Others are adjuncts of broader organizations such as labor unions or farm cooperatives. Still others are organized to deal broadly with consumer problems. In addition, there are broad consumer federations, national and international, which try to improve the collective strength of all local and specialized consumer groups.

Government Agencies. These exist at national, state, and local levels of government. All invite consumers to bring unresolved complaints to them as well as to report instances of business malpractice. These complaints aid the agency in identifying widespread problems, which, in turn, become the basis for:

1. Conducting investigations in depth
2. Proposing new legislation
3. Issuing new administrative regulations

The agencies also try to help complaining consumers, either in an ombudsman role or by threat of legal action. However, in practice, broad government agencies are unable to become involved in specific consumer grievances due to the sheer numbers. See below, under Government Regulation of Quality; The Enforcement Process.

No Remedy. Under the prevailing free-enterprise, competitive market system, many valid consumer complaints result in no satisfaction to the consumer. Nevertheless the system includes some built-in stabilizers. Companies which fail to provide such satisfaction also fail to attract repeat business. In due course they mend their ways or lose out to companies who have a better record of providing satisfaction. In the experience of the author, every other system is worse.

Perceptions of the Consumer Movement. There is wide agreement, including among business managers, that "the consumer movement has kept industry and business on their toes." There is also wide agreement that the consumer movement's demands have "resulted in higher prices." Despite this, most of the public feels that the "changes are generally worth the extra cost." Consumers feel strongly that the consumer advocates should consider the costs of their proposals. However, a significant minority of the consumers believe that the advocates do not consider the costs involved (Sentry 1976, pp. 39, 40, 42, 47).

GOVERNMENT REGULATION OF QUALITY

From time immemorial, "governments" have established and enforced standards of quality. Some of these governments have been political—national, regional, local. Others have been nonpolitical: guilds, trade associations, standardization organizations, and so on. Whether through delegation of political power or through long custom, these governing bodies have attained a status which enables them to carry out programs of regulation as discussed below.

Standardization. With the evolution of technology came the need for standardizing certain concepts and practices.

- *Metrology:* One early application of standardization was to units of measure for time, mass, and other fundamental constants. So basic are these standards that they are now international in scope.
- *Interchangeability:* This level of standardization has brought order out of chaos in such day-to-day matters as household voltages and interchangeability of myriads of the bits and pieces of an industrial society. Compliance is an economic necessity.
- *Technological definition:* A further application of standardization has been to define numerous materials, processes, products, tests, and so on. These standards are developed by committees drawn from the various interested segments of society. While compliance is usually voluntary, the economic imperatives result in a high degree of acceptance and use of these standards.

The foregoing areas of regulation are all related to standardization, and have encountered minimal resistance to compliance. Other areas do encounter resistance, in varying degrees.

Safety and Health of the Citizenry. A major segment of political government regulation has been to protect the safety and health of its citizens. At the outset the focus was on punishment "after the fact"—the laws provided punishment for those whose poor quality had caused death or injury. Over the centuries there emerged a trend to regulation "before the fact"—to become preventive in nature.

For example, in the United States there are laws which prescribe and enforce safety standards for building construction, oceangoing ships, mines, aircraft, bridges, and many other structures. Other laws aim at hazards which have their origins in fire, foods, pharmaceuticals, dangerous chemicals, and so on. Still other laws relate to the qualifications needed to perform certain activities essential to public safety and health, such as licensing of physicians, professional engineers, airline pilots. Most recently these laws have proliferated extensively into areas such as consumer product safety, highway safety, environmental protection, and occupational safety and health.

Safety and Economic Health of the State. Governments have always given high priority to national defense: recruitment and training of the armed forces; quality of the weaponry. With the growth of commerce, laws were enacted to protect the economic health of the state. An example is laws to regulate the quality of exported goods in order to protect the quality reputation of the state. Another example is laws to protect the integrity of the coinage. (Only governments have the right to debase the currency.) In those cases where the government is a purchaser (defense weapons, public utility facilities), government regulation includes the normal rights of a purchaser to assure quality.

Economics of the Citizenry. Government regulation relative to the economics of the citizenry is highly controversial in market economies. Some of the resistance is on ideological grounds—the competitive marketplace is asserted to be a far better regulator than a government bureau. Other resistance is based on the known deficiencies of the administration of government regulation (see below). Some of the growth of this category of regulation has been stimulated by the consumerism movement.

The Volume of Legislation. Collectively, the volume of quality-related legislation has grown to formidable proportions. A desk reference book (Kolb and Ross 1980) includes lists (in fine print) of appendixes as follows:

- 21 pages of exposure limits for toxic substances
- 93 pages of hazardous materials and the associated criteria for transportation
- 24 pages of American National Standards for safety and health
- 36 pages of Federal record-retention requirements
- 38 pages of standards-setting organizations

In the United States, much of this legislation is within the scope of the Federal Trade Commission, which exercises a degree of oversight relative to "unfair or deceptive practices in commerce." That scope has led to specific legislation or administrative action relative to product warranties, packaging and labeling, truth in lending, and so on.

In a sense these actions all relate to representations made to consumers by industrial companies. In its oversight the Federal Trade Commission stresses two major requirements:

1. The advertising, labeling, and other product information must be clear and unequivocal as to what is meant by the seller's representation.
2. The product must comply with the representation.

These forms of government regulation are a sharp break from the centuries-old rule of *caveat emptor* (let the buyer beware). That rule was (and is) quite sensible as applied to conditions in the village marketplaces of developing countries. However it is not appropriate for the conditions prevailing in industrialized, developed countries. For elaboration, see Juran (1970).

The Plan of Regulation.

Once it has been determined to regulate quality in some new area, the approach follows a well-beaten path. The sequence of events listed below, while described in the language of regulation by political government, applies to nonpolitical government as well.

The Statute. The enabling act defines the purpose of the regulation and especially the subject matter to be regulated. It establishes the "rules of the game" and creates an agency to administer the act.

The Administrator. The post of administrator is created and given powers to establish standards and to see that they are enforced. To this end he or she is armed with the means for making awards and applying sanctions on matters of great importance to the regulated industries.

The Standards. The administrator has the power to set standards and may exercise this power by adopting existing industry standards. These standards are not limited to products; they may deal with materials, processes, tests, descriptive literature, advertising, qualifications of personnel, and so on.

Test Laboratories. The administrator is given power to establish criteria for judging the qualifications of "independent" test laboratories. Once these criteria are established, he or she also may have the power to issue certificates of qualification to laboratories which meet the criteria. In some cases administrators have the power to establish their own test laboratories.

Test and Evaluation. Here there is great variation. In some regulated areas, agency approval is a prerequisite to going to market, e.g., new drug applications or plans for the operation and maintenance of a new fleet of airplanes. Some agencies put much stress on surveillance, i.e., review of the companies' control plans and adherence to those plans. Other agencies emphasize final product sampling and test.

The Seal or Mark. Regulated products are frequently required to display a seal or mark to attest to the fact of compliance with the regulations. Where the regulating agency does the actual testing, it affixes this mark; e.g., government meat inspectors physically stamp the carcasses.

More usually, the agency does not test and stamp the product. Instead, it determines, by test, that the product *design* is adequate. It also determines, by surveillance, that the companies' systems of control are adequate. Any company whose system is adequate is then authorized to affix the seal or mark. The statutes always provide penalties for unauthorized use of the mark.

Sanctions. The regulatory agency has wide powers of enforcement, such as the right to:

- Investigate product failures and user complaints
- Inspect companies' processes and system of controls
- Test products in all stages of distribution
- Recall products already sold to users
- Revoke companies' right to sell, or to apply the mark
- Inform users of deficiencies
- Issue cease-and-desist orders

Effectiveness of Regulation. Regulators face the difficult problem of balance—protecting consumer interests while avoiding creation of burdens which in the end are damaging to consumer interests. In part the difficulty is inherent because of the conflicting interests of the parties. However, much of the difficulty is traceable to unwise agency policies and practices in carrying out the regulatory process. These relate mainly to the conceptual approach, setting standards, the enforcement process, and cost of regulation.

The Conceptual Approach. An example is seen in the policies employed by the National Highway Traffic Safety Administration (NHTSA) for administering two laws enacted in 1966:

1. The National Traffic and Motor Vehicle Safety Act, directed primarily at the vehicle
2. The Highway Safety Act, directed primarily at the motorist and the driving environment

Even prior to 1966, the automobile makers, road builders, and so on had improved technology to an extent which provided the motorist with the means of avoiding the "first crash," i.e., accidents due to collisions, running off the road, etc. The availability of seat belts then provided the motorist with greatly improved means of protection against the "second crash." This crash takes place when the sudden deceleration of a collision hurls the occupants against the steering wheel, windshield, and so on.

At the time NHTSA was created, the United States' traffic fatality rate was the lowest among all industrial countries. It was also known, from overwhelming arrays of data, that the motorist was the limiting factor in traffic safety:

- Alcohol was involved in about half of all fatal accidents.
- Young drivers (under age 24) constituted 22 percent of the driver population but were involved in 39 percent of the accidents.
- Excessive speed and other forms of "improper" driving were reported as factors in about 75 percent of the accidents. (During the oil crisis of 1974 the mandated reduction of highway speeds resulted in a 15 percent reduction in traffic fatalities, without any change in vehicles.)
- Most motorists did not buy safety belts when they were optional, and most did not wear them when they were provided as standard equipment.

In the face of this overwhelming evidence NHTSA paid little attention to the main problem—improving the performance of the motorists. Instead, NHTSA concentrated on setting numerous standards for vehicle design. These standards did provide some gains in safety with respect to the second crash. However the gains were minor, while the added costs ran to billions of dollars—to be paid for by consumers in the form of higher prices for vehicles.

The policy is seen to have been one of dealing strictly with a highly visible political target—the automobile makers, while avoiding any confrontation with a large body of voters. It was safe politically but it did little for safety. For elaboration, see Juran (1977).

Setting Standards. A major regulatory question is whether to establish design standards or performance standards.

- Design standards consist of precise definitions, but they have serious disadvantages. Their nature and numbers are such that they often: lack flexibility, are difficult to understand, become very numerous, become prohibitive to keep up to date.
- Performance standards are generally free from the above disadvantages. However, they place on the employer the burden of determining how to meet the performance standard, i.e., the burden of creating or acquiring a design. Performance standards also demand level of compliance officers who have the education, experience, and training needed to make the subjective judgments of whether the standard has been met.

These alternatives were examined by a presidential task force assigned to review the safety regulations of the Occupational Safety and Health Administration. The task force recommended a "performance/hazard" concept. Under that concept, the standard would "codify into a requirement the fact that a safe workplace can be achieved only by ensuring that employees are not exposed to the hazards associated with the use of machines. Under this standard, the employer would be free to determine the most appropriate manner in which to guard against any hazard which is presented, but his compliance with the requirement is objectively measurable by determining whether or not an employee is exposed to the hazard." For elaboration, see OSHA Safety Regulation 1977. For added discussion, see Tye (1988).

The Enforcement Process. A major deficiency in the regulatory process is failure to concentrate on the vital few problems. Regulatory agencies receive a barrage of grievances: consumer complaints, reports of injuries, accusations directed at specific products, and so on. Collectively the numbers are overwhelming. There is no possibility of dealing thoroughly with each and every case. Agencies which try to do so become hopelessly bogged down. The resulting paralysis then becomes a target for critics, with associated threats to the tenure of the administrator, and even to the continued existence of the agency.

In the United States the Occupational Safety and Health Administration faced just such a threat in the mid-1970s. In response it undertook to establish a classification for its cases based on the seriousness of the threats to safety and health. It also recalled about 1000 safety regulations which were under attack for adding much to industry costs and little to worker safety.

With experience, the agencies tend to adopt the Pareto principle of vital few and useful many. This enables them to concentrate their resources and to produce tangible results.

Choice of the vital few is often based on quantitative data such as frequency of injuries or frequency of consumer complaints. However, subjective judgment plays an important role, and this enables influential special pleaders to secure high priority for cases which do not qualify as being among the vital few.

How to deal with the "useful many" needs for assistance has been a perplexing problem for all agencies. The most practical solution seems to have been to make clear that the agency is in no position to resolve such problems. Instead the agency provides consumers with information and educational material of a self-help nature: where to apply for assistance; how to apply for assistance; what are the rights of the consumer; what to do and not to do. See, for example, *Consumer's Resource Handbook* (1980).

The failure of regulators to deal forthrightly with such consumer problems has no doubt contributed to the mediocre status given to regulators by the public, in response to the question: which (of four options) would you like to be primarily responsible for the job of seeing that consumers get a fair deal? For elaboration, see Sentry 1976, p. 70.

A Rule for Choosing the Vital Few. In 1972 the author proposed the following as a quantitative basis for separating the vital few from the rest, on matters of safety:

> Any hour of human life should be as safe as any other hour.

To effectuate such a policy it is first necessary to quantify safety nationally, on some common basis such as injuries per million worker-hours of exposure. In general, the data for such quantification are already available, though some conversions are needed to arrive at a common unit of measure. For example, statistics on safety at school are computed on the basis of injuries per 100,000 student-days, motor vehicle statistics are on a per 100 million miles of travel basis, and so on.

The resulting national average will contain a relative few situations which are well above the average and a great many which are below. Those above the average would automatically be nominated to membership in the vital few. Those below the average would not be so nominated; the burden of proof would be on any special pleader to show why something below the national average should take priority ahead of the obvious vital few. For elaboration, see Juran (1972).

The Costs and Values of Regulation. The costs of regulation consist largely of two major components:

1. *The costs of running the regulatory agencies:* These are known with precision. In the United States they have risen to many billions of dollars per year. These costs are paid for by consumers in the form of taxes that are then used to fund the regulatory agencies.
2. *The costs of complying with the regulations:* These costs are not known with precision, but they are reliably estimated to be many times the costs of running the regulatory agencies. These costs are in the first instance paid for by the industrial companies, and ultimately by consumers in the form of higher prices. For an example of a study of industry costs, see The Business Roundtable (1978).

The value of all this regulation is difficult to estimate. (There is no agreement on what is the value of a human life.) Safety, health, and a clean environment are widely believed to be enormously valuable. Providing consumers with honest information and prompt redress is likewise regarded as enormously valuable. However such general agreements provide no guidelines for what to do in specific instances. Ideally, each instance should be examined as to its cost-value relationship. Yet the statutes have not required the regulators to do so. The regulators have generally avoided facing up to the idea of quantifying the cost-value relationship.

Until 1994 the support for studying the cost-value relationships came mainly from the industrial companies. For example, a study of mandated vehicle safety systems found that:

> "…states which employ mandatory periodic inspection programs do not have lower accident rates than those states without such requirements."

"…only a relatively small portion of highway accidents—some 2 to 6 percent—are conclusively attributable to mechanical defects."

"…human factors (such as excess speeds) are far more important causes of highway accidents than vehicle condition." For elaboration see Crain 1980.

The indifference of regulators to costs inevitably creates some regulations and rigid enforcements so absurd that in due course they become the means for securing a change in policy. The companies call such absurdities to the attention of the media, who relish publicizing them. (The media have little interest in scholarly studies.) The resulting publicity then puts the regulators on the defensive while stimulating the legislators to hold hearings. During such hearings (and depending on the political climate) the way is open to securing a better cost-value balance.

The political climate is an important variable in securing attention to cost-versus-value considerations. During the 1960s and 1970s the political climate in the United States was generally favorable to regulatory legislation. Then, during the 1980s the climate changed, and with it a trend toward requiring cost justifications. This trend then accelerated in late 1994, when the elections enabled the opponents of regulation to gain majority status in the national legislatures. For added discussion, see Dowd 1994.

PRODUCT SAFETY AND PRODUCT LIABILITY

Growth of the Problem. Until the early twentieth century, lawsuits based on injuries from use of products (goods and services) were rarely filed. When filed, they were often unsuccessful. Even if successful, the damages awarded were modest in size.

During the twentieth century these lawsuits have, in the United States, grown remarkably in numbers. By the mid-1960s they were estimated to have reached over 60,000 annually and by the 1970s to over 100,000 per year. (Most are settled out of court.) This growth in numbers of lawsuits has been accompanied by an equally remarkable growth in the sizes of individual claims and damages. From figures measured in thousands of dollars, individual damages have grown to a point where awards in excess of $100,000 are frequent. Damages in excess of $1,000,000 are no longer a rarity.

In some fields the costs of product liability have forced companies to abandon specific product lines or go out of business altogether.

> Twenty years ago, 20 companies manufactured football helmets in the United States. Since that time, 18 of these companies have discontinued making this product because of high product liability costs. (Grant 1994).

Several factors have combined to bring about this growth in number of lawsuits and in size of awards. The chief factors include:

- The "population explosion" of products. The industrial society has placed large numbers of technological products into the hands of amateurs. Some of these products are inherently dangerous. Others are misused. The injury *rate* (injuries per million hours of usage) has probably been declining, but the total *number* of injuries has been rising, resulting in a rise in total number of lawsuits.
- The erosion of company defenses. As these lawsuits came to trial, the courts proceeded to erode the former legal defenses available to companies.

  Formerly, a plaintiff's right to sue a manufacturer rested on one of two main grounds:

  A *contract* for sale of the product, with an actual or implied warranty of freedom from hazards. Given the contract relationship, the plaintiff had to establish "privity," i.e., that he or she was a party to the contract. The courts have in effect abolished the need for privity by taking the position that the implied warranty follows the product around, irrespective of who is the user.

Negligence by the company. Formerly the burden of proof was on the plaintiff to show that the company was negligent. The courts have tended to adopt the principle of "strict liability" on the ground that the costs of injuries resulting from defective products should be borne "by the manufacturers that put such products on the market rather than by the injured persons who are powerless to protect themselves." In effect, if an injury results from use of a product that is unreasonably dangerous, the manufacturer can be held liable even in the absence of negligence. (Sometimes the injured persons are not powerless. Some contribute to their injuries. However, juries are notoriously sympathetic to injured plaintiffs).

The literature on growth of the problem is extensive, as is the literature on proposals for remedy. See especially Harrington and Litan 1988 and references cited. See also Grant 1994; Smith 1991; Egington 1989; McGuire 1988; Wargo 1987.

Defensive Actions. The best defense against lawsuits is to eliminate the causes of injuries at their source. All company functions and levels can contribute to making products safer and to improving company defenses in the event of lawsuits. The respective contributions include the following:

- *Top management.* Formulate a policy on product safety; organize product safety committees and formal action programs; demand product dating and product traceability; establish periodic audits of the entire program; support industry programs which go beyond the capacity of the unaided company. To this list should be added a scoreboard—a measure of the injury rate of the company's products relative to an appropriate benchmark. A useful unit of measure is the number of injuries per million hours of usage, since most major data banks on injuries are already expressed in this form or are convertible to this form.
- *Product design:* Adopt product safety as a design parameter; adopt a fail-safe philosophy of design; organize formal design reviews; follow the established codes; secure listings from the established laboratories; publish the ratings; utilize modern design technique.
- *Manufacture:* Establish sound quality controls, include means for errorproofing matters of product safety; train supervisors and workers in use of the product as part of the motivation plan; stimulate suggestion on product safety; set up the documentation needed to provide traceability and historical evidence.
- *Marketing:* Provide product labeling for warnings, dangers, antidotes; train the field force in the contract provisions; supply safety information to distributors and dealers; set up exhibits on safety procedures; conduct tests after installation, and train users in safety; publish a list of dos and don'ts relative to safety; establish a customer relations climate which minimizes animosity and claims. Contracts should avoid unrealistic commitments and unrealistic warranties. Judicious disclaimers should be included to discourage unjustified claims.
- *Advertising:* Require technological and legal review of copy; propagandize product safety through education and warnings. Avoid "puffing"—it can backfire in liability suits, e.g, if a product is advertised as "absolutely safe." During advertising review, one of the questions should be "How would this phrase sound in a courtroom?"
- *Customer Service:* Observe use of the product to discover the hazards inherent during use (and misuse); feed the information back to all concerned; provide training and warnings to users.
- *Documentation:* The growth of safety legislation and of product liability has enormously increased the need for documentation. A great deal of this documentation is mandated by legislation, along with retention periods. (For a compilation, see Kolb and Ross 1980, pp. 547–584.)

Consumers exhibit a wide range of product knowledge, including the lowest. In consequence, actual use of the product can differ significantly from intended use. For example, some stepladders include a light platform which is intended to hold tools or materials (e.g., paint) but is not intended to carry the weight of the user. However, some users nevertheless do stand on these platforms with resulting injury to themselves.

Most modern policy is to design products to stand up under actual usage rather than intended usage. For added discussion, see Farrow 1991; see also Scofield 1986 relative to product labeling.

Defense against Lawsuits. The growth of product liability lawsuits has led to reexamination of how best to defend against lawsuits once they are filed. Experience has shown the need for special preparation for such defense, including:

- Reconstruction of the events which led up to the injury
- Study of relevant documents—specifications, manuals, procedures, correspondence, reports
- Analysis of internal performance records for the pertinent products and associated processes
- Analysis of field performance information
- Physical examinations of pertinent facilities
- Analysis of the failed hardware

All this should be done promptly, by qualified experts, and with early notification to the insurance company. For elaboration, see Gray et al. (1975, pp. 67–93); also Kolb and Ross (1980, pp. 275–286).

Whether and how to go to trial involves a great deal of special knowledge and experience. See generally, Gray et al (1975); also Kolb and Ross (1980, pp. 275–286).

Defense through Insurance. Insurance is widely used as a defense against product liability. But the costs have escalated sharply, again because of the growth in number of lawsuits and size of awards. In some fields insurance has become a major factor in the cost of operations. (Soaring insurance rates have forced some surgeons to take early retirement.)

Some comprehensive studies have examined the problem of insurance as applied to product liability. See McGuire 1988; Harrington and Litan 1988. See also Interagency Task Force Final Report on Product Liability (1978, chap. III), and Kolb and Ross (1980, pp. 287–327).

Prognosis. As of the mid-1990s there remained some formidable unsolved problems in product liability. To many observers the United States' legal system contained some serious deficiencies:

- Lay juries lack the technological literacy needed to determine liability on technological matters. In most other developed countries, judges make such decisions.
- Lay juries are too easily swayed emotionally when determining the size of awards.
- In the United States, "punitive damages" may be awarded along with compensatory damages and damages for "pain and suffering." Punitive damages contribute greatly to inflated awards.
- In the United States, lawyers are permitted to work on a contingency fee basis—a concept that assertedly stimulates lawsuits. This arrangement is illegal in most countries.
- The adversary system of conducting trials places the emphasis on winning rather than on doing justice.
- Only a minority of the award money goes to the injured parties. The majority goes to lawyers and to pay administrative expenses.

By the mid-1990s some elements of this legal system were under active review in the national Congress. However, the system which has endured these deficiencies is deeply rooted in the United States culture, so it is speculative whether it will undergo dramatic change. A major obstacle has been the lawyers. They have strong financial interests in the system, and they are very influential in the legislative process—many legislators are lawyers.

In most developed countries the legal system for dealing with product liability is generally free from the above asserted deficiencies. Those same countries are also largely free from the extensive damage which product liability is doing to the United States economy.

(For some incisive comments on the deficiencies in the United States' legal system, see Grant 1994.)

Personal Liability. An overwhelming majority of product liability lawsuits have been aimed at the industrial companies; they and their insurers have the greatest capacity to pay. As a corollary, such civil lawsuits are rarely aimed at individuals, e.g., design managers or quality managers. These individuals have little cause for concern with respect to civil liability. They are not immune from lawsuits but they are essentially immune from payment of damages.

Criminal liability is something else. Now the offense (if any) is against the state, and the state is the plaintiff. Until the 1960s, prosecution for criminal liability in product injury cases was directed almost exclusively at the corporations rather than the managers. During the 1960s and the 1970s the public prosecutors became more aggressive with respect to the persons involved. The specific targets were usually the heads of the companies but sometimes included selected subordinate managers such as for product development or for quality.

A contributing factor has been an earlier provision of the Food, Drug and Cosmetic Act making it a crime to ship out adulterated or misbranded drugs. This provision was interpreted by the United States Supreme Court to be applicable to the head of a company despite the fact that he or she had not participated in the events and even had no knowledge of the goings-on. For an analysis, see O'Keefe and Shapiro (1975). Also O'Keefe and Isley (1976).

For the great majority of industrial managers the threat of criminal liability is remote. Before there can be such liability, the manager must be found guilty of (1) having *knowingly* carried out illegal actions or (2) having been grossly negligent. These things must be proved to a jury beyond a reasonable doubt. It is a difficult proof. (Many guilty criminals escape conviction because of this difficulty.)

ENVIRONMENTAL PROTECTION

A special category of government regulation is environmental protection (EP). On the face of it, EP is a twentieth-century phenomenon. However, there is a school of thought suggesting that EP originated in a conservation movement to preserve lands that were being exploited by European colonists during the seventeenth and eighteenth centuries. For elaboration, see Grove 1992.

The Industrial Revolution of the mid-eighteenth century opened the way to mass production and consumption of manufactured goods at rates that grew exponentially. To support this growth required a corresponding growth in production of energy and materials. The resulting goods conferred many benefits on the societies that accepted industrialization. However, there were unwelcome by-products, and these also grew at exponential rates.

Generating the needed energy produced emissions that polluted the air and water. Nuclear power created the problem of nuclear waste disposal as well as the risk of radiation leaks. Mining for raw materials damaged the land, as did disposition of toxic wastes. Ominous threats were posed by ozone depletion and the risk of global warming. Disposition of worn-out and obsolete products grew to problems of massive proportions. All this was in addition to problems posed by the numerous inconveniences and occasional disasters caused by product failures during service. (See above under Life behind the Quality Dikes).

Industrial companies were generally aware that they were creating these problems, but their priorities were elsewhere. Public awareness lagged, but by the mid-twentieth century the evidence had become overwhelming. Responding to public pressures, governments enacted much legislation to avoid worsening the problem, and provided funds to undo some of the damage.

The new legislation was at first strongly resisted by industrial companies because of the added costs it imposed. Then as it became clear that EP was here to stay, the ingenuity of industry began to find ways to deal with the problem at the source—to use technology to avoid further damage to the environment. A striking example is Japan's achievement in energy conservation. During the period 1973–1990, despite continuing growth in industrial production, there was no increase in energy consumption (Watanabe 1993).

Public and media preoccupation with specific instances of environmental damage has tended to stimulate allocation of funds to undo such damage. However the long-range trend seems to be toward

prevention at the source. A recent survey estimated that during 1991, of the research and development budgets of United States industrial companies, about 13 percent was directed at technology to minimize environmental damage (Rushton 1993).

Recognition of the importance of EP is now evident in many ways. For example:

- Many countries have created new ministries to deal with the problem of EP.
- Many industrial companies have created high-level posts for the same purpose.
- Numerous conferences are being held, including at the international level, with participation from government, industry and academia (Strong 1993).
- An extensive and growing body of literature has emerged. Some of this is quite specific. See for example on asbestos, Mossman et al. 1990; on design for recycling, Bylinsky 1995; also Penev and de Ron 1994.
- Companies have also evolved specific processes for addressing the problems of EP. These generally consist of:

  Establishment of policies and goals with respect to EP.

  Establishment of specific action plans to be carried out by the various company functions.

  Audits to assure that the action plans are carried out.

In addition, the ingenuity of companies has begun to find ways to reduce the costs of providing solutions. Table 35.2 lists some of the identified problems and the associated opportunities for solution (Rushton 1993).

TABLE 35.2 Environmental Problems and Opportunities for U.S. Industry

Problem	Opportunity
	Performance chemicals and materials
Air pollution	Emission control catalysts, clean motor fuels
Hazardous substances	Asbestos substitutes, chlorine substitutes, PCB substitutes
Land pollution	Lagoon liners
Oil spills	Oil absorbents, surfactants
Ozone layer depletion	CFC substitutes, UV hazard reduction technologies
VOC emissions	Power coatings, radiation-cured coatings, water-based coatings
Water pollution	Water treatment chemicals
	Food
Caffeine	Supercritical fluid extraction
Disposable packaging pollution	Recyclable or degradable packaging
Fat	Fat substitutes, “lite” foods
Short shelf life	Antioxidants, aseptic packaging, controlled/modified atmosphere packaging
Sugar	Low-calorie sweeteners
	Environmental management
Hazardous substance treatment	Asbestos removal, waste remediation
Hazardous substance prevention	Process redesign, spent oil recycling, waste prevention and minimization
Pollutant detection and monitoring	Analytic laboratory services, sensors
Solid waste storage and disposal	Waste recycling, incineration
Water supply	Low water consumption processes, water purification, water recycling
	Health care and safety
Automotive safety	Air bags, antilock brake systems
Bioincompatibility, rejection	Thromboresistant biomaterials, biodegradable implants
Disease diagnosis and treatment	Diagnostic reagents, instruments, services

TABLE 35.2 (Continued)

Problem	Opportunity
	Health care and safety
Equipment safety	Inspection and testing services
Medical waste pollution	Medical waste minimization, incineration.
Personal safety	Flame-retardant materials, protective clothing
Product tampering	Tamper-evident packaging
Side effects of drugs	Controlled-release drug delivery systems, biosensors

Source: Rushton (1993).

The emerging consensus is that the best solution lies in industrial efficiency (Strong 1993).

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