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THE KEY ROLE OF QUALITY CONTROL AND CERTIFICATION MARKING PROGRAMS IN DEVELOPING COUNTRIES[1]

by

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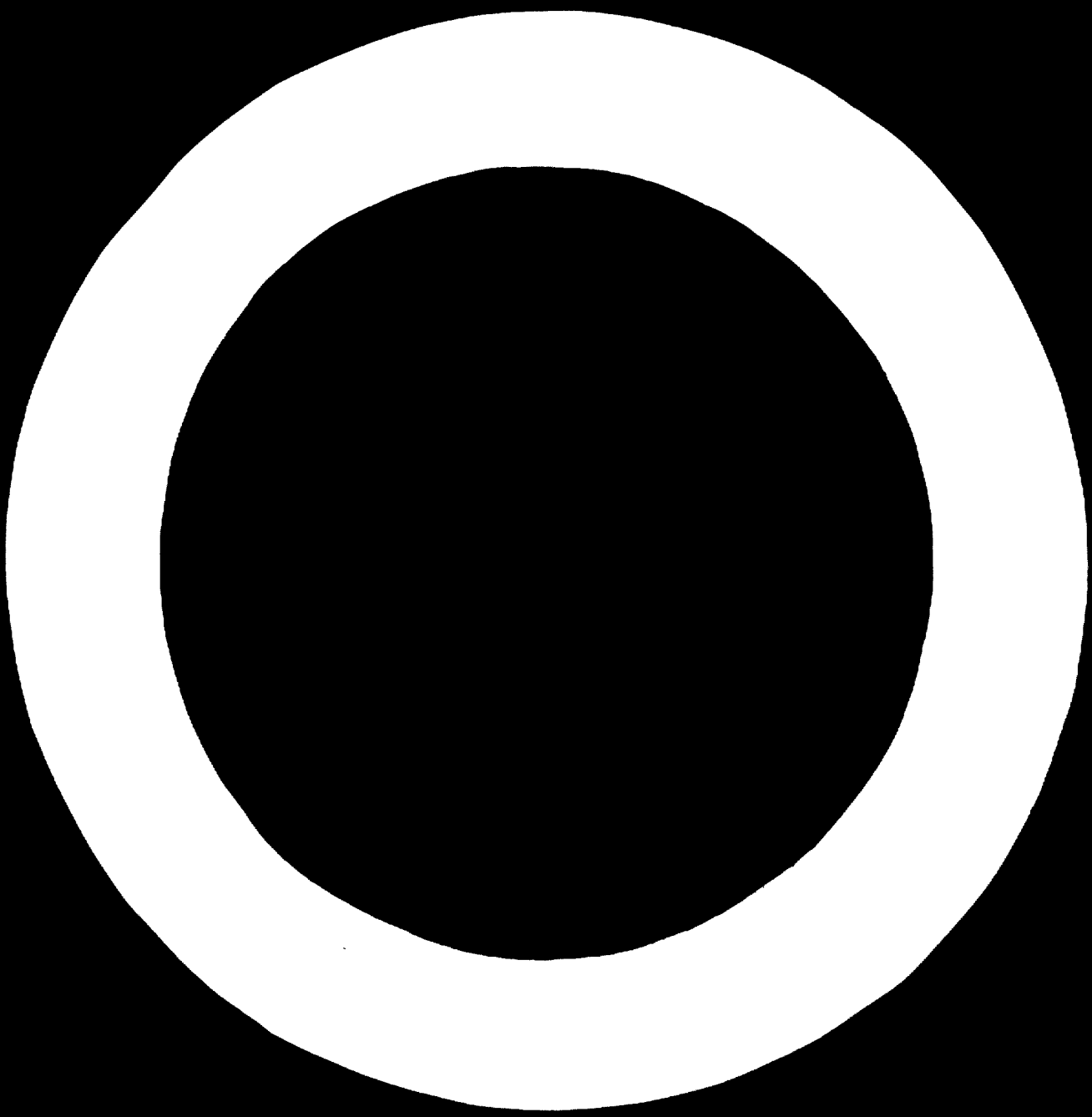

The underlying assumption in the development of emerging countries in Southeast Asia, as well as throughout most other undeveloped parts of the world, is that technology is an effective technique for overall economic improvement and the catalyst for a better life. The assumption is that improved and expanded technology will lead to orderly economical, political, and social change, primarily by industrial growth and expansion. The actual rate of change depending on effective government policy, the general business and financial climate in that country or area of the world, the availability of natural resources, and many other major and minor factors.

To help accelerate this industrialization process the U.ited Nations Industrial Development Organization (UNIDO), in cooperation with the United Nations Development Program (UNDP) and others, organizes, supports and implements a variety of technical assistance programs to expand the base and scope of technical programs in all developing countries. Many of these UNIDO programs have been quite significant in their effects, and this conference is another example of UNIDO's keen awareness to different modes and emphasis of technical assistance as technologies throughout the world continue to expand at an ever increasing rate. Hopefully, it is

through such programs as these that people from more developed countries can help the less developed nations to improve their social, economic, and environmental conditions. To be effective we must articulate goals and program objectives that are realistic for the given conditions, and nurture technical techniques that are general in nature, yet can be tailor made for actual application in the emerging country.

We should also try to do those key things which will help a country to industrialize, recognizing that such assistance should be to help build a foundation upon which the people of the country can then generate their own industrial technology, from their own national point of view, to better serve their own unique needs and goals. The industrial development should be an individual one where countries are concerned, i.e., it should be something like a personal wardrobe, individually tailored to fit a particular way of life and appropriate to their needs and their conditions. In addition, for industrialization to be viable, it must interact effectively with the economic, social, political, and legal structures of that country.

How do we proceed? What do we do? We should furnish tools, techniques and concepts that cannot only be used in general, but at the same time can be molded or modified to fit the particular technical circumstances and constraints. For example, if we were concerned with the improvement and final approval of a quality control system for a particular industry, we would prepare a *general*

quality control manual for that industry, possibly based on an existing quality control standard such as the U.S. standard, Mil. Std-Q-9858A, "Quality Control Systems Requirements". However, our new manual would be more detailed to enable the quality control personnel in that particular industry to organize the required system by themselves or with some guidance, and also to enable them to adapt it to their present average level of know-how and technical understanding of their processes. The manual would be designed so that both large and small companies in the industry could make use of the concepts and techniques presented, and explained, hopefully, by practical examples. The manual would serve both the government standards institute and the company as a guide for working out its own quality control manual, containing a description of its organization and all the detailed and particular procedures, forms, inspection records, etc., especially adapted to its plants or operations. This approach would assist the standards institute in establishing quality control and standardization programs leading to quality certification or marking applications.

It should be noted that this particular illustration is what I would like to call a "software" example, and further that the tools and techniques of the software portion of technology implementation are the key factors to this implementation and strong viable industrial growth. For software tools and techniques are general in nature but broad in potential application, and powerful

for individual application and use. In contrast to most hardware approaches necessary for industrialization,which by their very nature can be very limited or highly specialized, many software methods have wide applicability, serving as a vehicle to help reach the final production goal within the ever present real-life constraints. Thus, I am suggesting that if development of technologies is the best long range answer to the social and economic development of emerging countries, which largely depends on their own sources and strengths, then an important overall approach is application of the software techniques of modern quality control and improvement. Among these are the important concepts of standardization and quality certification, which depend heavily on the software principles of industrial statistics and its applications in quality control and improvement.

Industrial statistics is a key and unique software tool because its forte is real problems, i.e., the real world of industrialization is complex and subject to many influencing factors and their interactions, which can only be properly handled and understood by applied statistical techniques. Furthermore, statistics can truly be international, yet does not require large dollar investments per se, but rather is applied through education and training, which can also contribute to the overall cultural growth of the emerging nation. Furthermore, this particular software tool can play a unique role in helping develop nations who want to short-circuit some of the long-term evolutionary developments

of the more developed countries. For example, one of the major advantages of using statistically designed experiments for testing and comparison in quality improvement programs is that these applied statistical methods increase the rate of convergence to the solution and at the same time increase the chances for successful experimentation. Such an approach is applicable in any stage of growth, and it can help developing countries play technological "leapfrog", increasing their rate of catching up to the more developed countries.

Statistical quality control methods and statistically designed experiments are two of the more developed and understood software techniques in industrialized countries. Engineering reliability theory is also being applied more widely as interest has increased greatly in the last decade. A more recent software tool to the modern industrial scene is time series analysis for process control and adaptive quality control.

If we recognize the need for a technological base for economic, social, and cultural growth, and the need to make maximum use of software techniques to sustain and expand the technological complex, then we also need to recognize that the integrity of the workers, management, and government officials is the moral fiber that greatly strengthens and supports an advancing industrial technology. At the same time a national integrity can help build and reinforce a national quality conscienceness in technical

programs as well as personal well being. Meaningful industrialization and economic expansion cannot take place without quality or integrity of all products nor without morality or integrity of all people concerned. Explicit recognition of this condition can provide the vital link between technical knowledge, the consequences of its use, and the inherent social dynamics of the developing society, which will vary from country to country. However, the principles involved are clear and when properly applied to each socioeconomic situation lead to increased progress in all facets of an emerging society.

In particular, organization and creation of quality certification or marking programs, both for local as well as international markets, are highly dependent on both the principles of quality or integrity and on the analytical principles of industrial statistics. The certification marking system must be designed with these principles in mind and the means selected to induce industries to improve their quality control systems will also be governed by these principles. As local industry becomes aware of the need to introduce and improve quality control, progress will be rapid if these principles are employed, and the status quo can be avoided.

I feel these are the basic tenets in the organization and administration of quality inspection and certification marking programs which must depend heavily on the cooperation, ability and attitude of the industry or company. For example, if a government

wishes to supervise exports for compliance with quality standards, it could have government inspectors sample all shipments, but with increasing exports from expanded industrialization this will become completely impractical. Therefore, supervision of exports will probably have to be transferred to a government institute such as a standards institute to supervise the quality control systems of companies manufacturing for export, rather than just their shipments. Thus we will require programs that involve a great deal of interaction between industry and the institute, and the ultimate success of the operation will depend on the mutual trust and respect which can be developed and maintained between the two parties under changing economic and social conditions. Increased size and complexity of the industrial enterprizes will only add to the need for recognition and application of the basic principles for development of viable technologies, and will require a system approach, an organized, mathematical, structured, objective approach to the total systems problem, which is the emerging country. On an even larger scale there will be need for international and regional co-operation, and the principles of quality and integrity can again serve as the basic tenets of this co-operation in the operation of quality certification or marking programs.

In the following sections the concepts discussed above will be covered in more depth, and specific illustrations will be given to help convey the important ideas. The need for a planned

and co-ordinated approach to standardization and quality control will be discussed, as well as the role of government and its organizations in improving the quality of goods manufactured in the emerging country. The responsibilities of the manufacturers and other national organizations such as public utilities, as participants in the quality assurance and certification marking system will also be included. In all this the interactions of technology and society must be recognized so that a strong and viable industrialization can grow within the structures native to a country and provide a base for lasting social, economical and environmental changes. In a world in which demand seems to increase more rapidly than resources become available, we must move forward on a homogenous and sound basis, such as furnished by standardization and certification.

SOUND QUALITY CONTROL PROGRAMS

Consistent production of quality products does not happen by chance, and there is a continuing need for sound quality control programs in all industry and business. The control of quality is the responsibility of everyone in the enterprise, and a concentrated effort by workers and management alike is required—beginning with the initial design and continuing as long as the product is manufactured. A quality control program, when integrated with each design and manufacturing function, reduces the chances of a substandard product reaching the market place and very much helps

to attain one of our goals of industrialization: satisfied customers as a means for continued economic expansion.

A sound quality control program is an effective system for the prevention, detection, and correction of product defects that would cause customer dissatisfaction or costly interruptions to production schedules. The system is designed to detect quality problems at the earliest possible stage of the design or manufacturing sequence in order to permit corrective action to be taken, in many cases without requiring a change or compromise in cost, quality, or production schedule. Early quality problem detection minimizes both dollar and time losses; an increase in production time can be very important, possibly more important than actual dollar losses when a new product is being introduced. This business nature of the quality problem emphasizes the necessity to stress the prevention capabilities of an effective quality control program rather than just correction of quality problems. A complete quality control program will insure a company's competitive position in both national and international markets and help to maximize profits. A properly designed program pays its own way many times over with both revenues and savings.

Quality control or quality assurance begins with product inspection and it never ends. In this product development cycle there are three basic phases: design, compliance to design, and performance; and each of these three broad areas in the operation of an industrial enterprise must be closely integrated with the

quality assurance program. The quality of design must be distinguished from quality of compliance, and both of these form quality of performance.

The quality of design is concerned with the stringency of the design specifications for the manufacture of the product. A difference in specification or specifications for the same functional use is a difference in quality of design, often called "grade". Quality of design is greatly influenced by the market for the product, and generally the greater the specified requirements for precision, reliability, strength, interchangability of a manufactured item, etc., the better the quality of design. The Mercedes and the Volkswagen automobiles serve the same basic functional use, but they differ in many features of design and are therefore different in quality of design, which results in different design specifications.

Quality of compliance, on the other hand, is related to the faithfulness with which the product compares to the original design requirements, i.e., how well the manufactured part conforms to design specifications. A Volkswagon which can operate and one which cannot, have the same quality of design, but they differ in quality of conformance. In addition, both manufacturers of the Mercedes and the Volkswagon have problems in quality of compliance—that is, producing Mercedes and Volkswagon that meet the respective design requirements. Quality assurance is closely

associated with compliance or conformance quality, and it is this area where most of the statistical techniques for sampling and control have been used.

A complete program for achieving quality assurance requires consideration of both the quality of design and the quality of conformance to design, and this joint consideration is the quality of performance. That is, the product is put to use and how it performs is dependent upon both the quality of design and the quality of conformance. The product can have the best possible design but poor control of conformance to design can cause poor performance. Conversely, the best conformance control cannot make a product function properly if the design is not right. Neither the Mercedes nor the Volkswagon will operate correctly if the engine manufacture or body assembly is done incorrectly.

There are optimum levels with respect to cost of both the quality of design and the quality of conformance. These levels have to be determined by management and will involve "tradeoffs" or compromises between cost, delivery schedules, and product quality. A poor quality program will result in excessive rework or scrap costs and/or late deliveries for sales. A good quality program may cost more initially (e.g., fixed investment costs, training costs, initial costs of insepction equipment, etc.) but the program will more than pay its way in reducing quality losses (both tangible and intangible) and late deliveries due to

poor quality. In addition, quality problems come largely from a small percentage of the quality characteristics of the products and usually account for a major percentage of all quality losses. This greatly narrows the area of profitable cost control applications and assures maximum return on the quality control investment. Thus, we should look upon quality control as a profit maximizing activity, for proper use of this management tool will permit products to be manufactured at the lowest possible cost for the quality level desired.

A good quality program is also an insurance program for many reasons. Customers return to select a certain product because they have learned that they can rely on the quality of the product. The sales organization can promote and sell confidently with the knowledge that the product delivered to the customer will be as represented. Company management can plan for the future with confidence that sales will not decline because of customer disappointment. Finally, both the customer and the manufacturer are comforted by the knowledge that the product has been produced in a quality control environment.

QUALITY CONTROL PROGRAMS IN DEVELOPING COUNTRIES

Sound quality control starts with education and training, for it is people who implement effective quality control. Quality control education and training for everyone from top management to the rank-and-file workers in each and every department must be

promoted and sustained. If provisions are not made for improvement of the quality level of these people, good quality control will not be attained. The end product of this education and training is not just quality production; it is also pride. Pride in workmanship can permeate a whole company, an industry, a nation. A tradition of quality production is one in which everyone can take pride.

The underlying principles and appropriate techniques of quality assurance are well known, but each developing country will require a somewhat different application for varying cultural environments. Therefore the ideal designers and implementors of a national quality movement which can contribute significantly to industrialization should be the indigenous people of that nation. However, the opportunity to learn from the experience of others and to avoid mistakes which were made elsewhere should be fully exploited whenever and wherever possible. These opportunities include the availability of individual quality control experts or teams of consultants to help in a variety of ways- from assisting in carrying out pilot projects in quality control in different manufacturing plants to helping plan, organize, and take-part in extensive education and/or training courses for all levels of production personnel. The lessons and experience provided by such authorities should be carefully learned so that they can be experimented with wisely and applied with considerable diligence.

Every country will have unique control factors that will determine the extent to which it can adopt quality control, but it must strive for complete utilization in order to take full advantage of technological developments.

With such a base, a country can build an education and training program in quality control. This program will consist of a diversity of ways for meeting its objective, including sending qualified people to foreign universities, colleges, and/or industrial education programs, as well as development and expansion of extensive educational activities at home. Both elementary and advanced quality control courses should be arranged for on a regularly scheduled basis, as well as the periodic organization of symposiums, conferences, and lectures on quality control and related subjects (such as experimental design). Larger companies, recognizing the need for more modern quality control systems, should organize in-plant training courses and lectures on quality control. Experience in the more developed countries in the field in industrial quality control shows that education and training are the principal conditions ensuring the desired success. This education can be formal or informal, but if the graduate works in an environment which is not conducive to continuing quality control education, the graduate will soon forget what was learned in the classroom. Quality control education must be supplemented by a company climate which motivates the individual operators to want to produce good quality, and this is the responsibility of top management.

What is the responsibility of the government in the organization and operation of quality control programs in an emerging economy? It must provide a means or a vehicle for focusing its attention on the promotion of industrial quality control programs and as we shall see later, for developing national standards and official quality certification or marking schemes. A good starting place on a limited scale, since it would not be concerned with standards nor certification programs could be a productivity institute, which would furnish the necessary technical knowledge for aiding small companies in introducing the beginnings of a quality control system. Also the institute's educational and training programs for improving productivity can include complementary courses in quality and process control, as well as the sponsorship of conferences, seminars, and workshops which would include the role of quality assurance relative to other management concerns.

On a larger scale and for the long term promotion of a viable program of national quality consciousness, the government will need a standards institute, probably within a ministry of industry, commerce or finance, to serve as the catalyst in the development of industrial quality control programs both large and small, for the expanding technological base and hopefully for a growing national and international market. The overall goal is to aid, not deter, in the introduction and operation of quality programs in industry. It must establish with industry a rapport and confidence such that companies with quality problems will confide

in the institute, and not try to hide quality problems just to meet production schedules and sales commitments. In this way the institute can truly help and induce companies to improve their quality control systems, and in that sense make the institute's job easier, for an exceptionally severe responsibility falls upon the authority that sets the pass/fail level of acceptability of commercial products. Furthermore a consensus, such as an industrial standard, is needed to set the minimum level of acceptability, and both industry and government must share this burden if the quality activity is to be successful.

Specifically, the standards institute's quality control section or department should offer consulting services in quality control and technical assistance in solving specific quality problems to companies requesting such services. These services should be government subsidized to a small degree to encourage companies to use such services. However, under no circumstances should such services be almost or completely free, for then the recipients will take the advice highly instead of seriously, to the detriment of the overall program of activities. The institute must be able to furnish appropriate technical advice that their customers can use and apply, and therefore have confidence in the institute's technical abilities and be willing to pay for it on a business basis. This is a very important policy in the

operation of a national program, for it is a voluntary means to induce industries to improve their quality control programs before the natural economic factors in industrial development exert their pressures for a greater national quality concern.

Educational programs of the standards institute are another voluntary means which the government can subsidize to show its readiness to aid training and promotional programs in quality control. In this area, the government must recognize that quality control engineers and technicians will be few and the problem can become acute with the shortage of manpower in general and technical personnel in particular. It should be recognized that training courses must be sufficiently coordinated between different educational institutions, and well stratified according to the previous education and present positions of the students. These educational activities must also recognize that some companies, e.g., the large international concerns, have already reached quality control levels far beyond the basics and probably have introduced quality engineering and quality management functions in addition to basic inspection systems, which are usually the early stages of quality control in an emerging country. At the same time, many companies are however still at the elementary stage of transforming inspection into effective quality systems and just beginning to apply modern quality engineering and statistical software methods. As a more progressive, even sophisticated stage in quality control is reached, usually based on advanced

technological know-how, the standards institute will have to have responsive management to keep pace with a dynamic national quality movement. For even after a breakthrough in attitude toward quality control is achieved, much will remain to be accomplished in training and assisting industries to reach the desired results.

Besides the voluntary means described above there are two other main ways the government can induce companies to improve their quality control programs. There are direct mandatory means and indirect or partially mandatory means. In the former there should only be selective application of mandatory means or the whole program will become impractical. For example, when food products are first exported a government will usually closely supervise these exports through the use of government inspectors to sample shipments; but with increased exports this becomes completely impractical and another approach must be taken. Principles should be adopted so that mandatory export quality control in all fields of industry can be handled adequately and properly. Such principles will also be applicable to quality certification programs, which will supplement and complement export quality activities.

One principle is that companies with an adequate quality control system, willingness to cooperate, and which show steady long term improvement in their quality control programs could receive exemption from inspection of national or international

shipment for periods ranging from three to six months. Such companies would be required to meet all minimum requirements for an effective quality control system as best tailored to each situation (kind of product, size of plant, nature of production process, etc.), and to keep detailed production records and records of each production quality or each shipment's quality. Personnel of the government's standards institute would visit each plant periodically, but not on a fixed schedule, to check production control and product quality records, and carry out verification tests of current production or shipments in order to compare with those recorded by the company. The institute's personnel would record their findings, which would be filed for future periodic summarization and evaluation. Companies could be classified according to their quality performance, and the frequency of plant visits and product amount to be checked by the institute would depend on this classification. Companies would be informed of the institute's findings, the nature of any recurring quality defects, and encouraged to take advantage of any assistance for solving quality or quality related problems at the company's expense. The results of such a program can be very positive, and the effectiveness of such an approach has been well demonstrated.

An indirect means of the government, which has a mandatory effect, is through large public purchasers such as the defense forces, local governments, municipalities, housing boards, public

utilities, etc., which can directly influence the quality of products manufactured in the country. For, unlike the individual consumer, such large governmental type bodies usually can precisely define their requirements in clear technical specifications, and, with extensive testing or engineering facilities usually available to them, ascertain whether their technical terms are met. This approach can also be effective if these bodies require many of their purchases to be locally certified by the government standards institute. It should be noted however, that this does not imply that laws and regulations should be passed requiring specific types of purchases to be made by each responsible public body; rather the secret to success in this area is that the technical arms of these public bodies recognize on their own the quality and reliability advantages of requiring certified quality products, and independently give the certifying institution such as the standards institute a vote of confidence that will be deserved. For those government agencies and public institutions that do not possess the facilities and know-how to perform acceptance tests on the various products they purchase, the government's standards institute could perform this quality assurance function for them.

It should also be noted that to fully and effectively carry out its responsibilities, the standards institute must not only have technical software capabilities but also extensive technical hardware facilities and capabilities for carrying on the myriad

of acceptance and quality conformance testing required for checking and certification. Ideally such a capability will include advanced engineering and scientific personnel who can direct and back-up the testing facilities, particularly when trouble-shooting is necessary or other difficult quality problems are encountered. This advanced technical capability can also be utilized for sponsored industrial research projects, particularly for those involving indirect quality and reliability improvements or changes. Such an arrangement enhances the overall technological competance of the institute to help it spur companies and industries to take action to improve their quality control systems and to enable it to respond to the expanding quality control activities that will take place as the country becomes more and more industrialized. For, as quality control methods are introduced into an increasing number of industries and results of pioneers in the field are reported, others will follow suit.

QUALITY CERTIFICATION MARKING PROGRAMS

The primary reason behind any certification program is to make easier the identification of products which meet certain standards. For even if an excellent standard for a product exists, how is the consumer to know whether the product purchased meets the standard-possibly requiring both certain safety and performance qualities -unless it is identified in some manner. This manner should indicate that

the standards institute certifies that the product does in fact meet the set standard. More importantly, a recognizable method for certifying product quality is necessary to improve a manufacturer's ability to export product throughout the world, and thus contribute to the economic development of the emerging country.

Certification is a valid quality assurance function and the standards it is based on also aid in the manufacture of and procurement of quality products In fact, standards of manufacture, performance, and safety are the keys to successful internationalization of products. The use of mutually acceptable standards containing information on pertinent characteristics and testing and measuring procedures will satisfy both buyer and seller. The cost for receiving inspection, longer acceptance and life testing, and the cost of rejection (discounts or shipment costs and administrative costs) will be substantially lower with a realistic certification scheme. With a certification program the consumer has assurance-security- and will buy, satisfied with the knowledge that the product is worth the price when its quality is identified.

In principle, products manufactured and tested in accordance with published standards and attested to by the certifying organization - indicating that the manufacturer's tests and quality controls are in accordance with the published standard - would be accepted by the purchaser (importer) in the everyday course of business. In practice, a product would be subjected to examination and testing within the manufacturer's facility, or tested and evaluated by the

standards institute who, when appropriate, would certify that certain characteristics of the product exist in accordance with the standard. That is, any certification system based on standards should utilize to the maximum extent, where they exist in appropriate form and suitable precision, the internal quality control procedures of manufacturers where products are being certified, and should encourage the development of these procedures.

As the economy expands, the business wealth of the developing country will be more dependent than ever before upon the ability of management to apply quality control and reliability technologies for the purposes of insuring that products and services they control satisfy the consumer, and a national certification program will insure that these conditions are fulfilled. Also, as technical progress develops, the ties between standardization and quality control will become still closer, and it is natural that the responsibility for an effective certification program should rest with the institution responsible for overseeing the development and improvement of quality control systems. This public body will be the most familiar with the dominant role of quality control to assure that products conform to requirements, safeguards, and standards, and it will have the fullest understanding of how standards should and can be developed.

However, the actual drafting and adopting of standards should be the responsibility of a third independent party, with only an indirect connection with the institute for proper communication,

interchange, and feedback of pertinent technical information. This third party should be made up of experts in their respective fields from industry, government, and education, who have separate but complementary technical interests in the standard to be developed, and who possess the collective judgement to decide if a completely new standard is required or whether an existing standard can be adopted as is or with some modifications. They should have the technical scientific, and engineering facilities of the institute at their disposal if questions about certain technical aspects of the standard must be answered, yet be autonomus, so that they can be unbiased in their deliberations. Once a standard is formulated, it is up to the institute to see that it is applied properly and to use it as a basis for the quality certification marking program. It is also incumbant that this independent organization for sponsoring and adopting standards insure that its standards reflect existing technology, and are kept current and adequately up-graded to allow for technological innovation.

In addition, there will be need for a legal basis and method by which the standards institute licenses the producer or vendor to use its certification mark. A licensing contract would be appropriate, which would contain a written procedure, possibly tailored for each standard, setting forth a continuing inspection and follow-up program to be performed by the institute. The responsibility for all reasonable costs incurred in the operation of the certification program would be included in the licensing contract. The mark

should at all times be under the control of the standards institute, who can issue it as well as withdraw it if conditions so dictate. Conditions leading to withdrawal should also be spelled out in the certification licensing agreement. The principle being that the certification is optional, but not guaranteed.

A quality certification marking program can be a fundamental framework for expanding the national and international market, but it must be equal in severity and actual policing. It should be applied with fairness and equal rigidity to every company that uses the certification system, so that no company has a commercial advantage in the looseness of the system. Thus, quality certification can become a major vehicle in promoting technical progress and standards a major vehicle in the assimilation of new, high quality products.

SOFTWARE TECHNOLOGY

In the introduction it was pointed out that a key factor in the growth of the economy is the software portion of the industrialization process. Within this software portion are the important techniques of standardization and quality control, which have been discussed. Initially in a developing technology these software applications are the most important ones, but for continued growth it will also be necessary that advanced methods of industrial statistics be introduced for more progressive and sophisticated stages of quality control and improvement. These advanced methods

would include: design of experiments, product reliability, and stochastic process control. These advanced methods will be applicable at different stages of industrial growth and expansion of quality control programs. The first could be especially important to developing countries, for it could help them increase their rate of catching-up to the more developed countries and at the same time the emerging nation would benefit from process quality improvements, which are so vital to a dynamic industrialization effort.

Modern statistical experimental design techniques have been formulated to efficiently assist production and process improvement studies, which are and should be carried on continuously in industry for overall quality improvement. That is, a very important activity in any company is the continuous comparison of old and new manufacturing methods, production processes, product designs, etc. There is a never-ending search for new techniques to improve the quality and reliability, as well as reduce the cost, of the finished product. This comparison process will be going on formally or informally, and the company is constantly faced with very important decisions of whether to make a processes production change or not. These comparisons will require a testing and/or experimentation program, and it is obvious that for such a program to be fully effective and successful it must be properly planned so that the resulting process changes do lead to increased quality and reliability. Therefore, experimental design techniques should be used which

can minimize the costs of testing and experimentation, while at the same time greatly increase the chances for successful quality improvements.

The experimental design techniques have been developed to assist the experimenter in both the planning of the experiment as well as in the analysis of the observed data or results. The methods are such that the experimenter can maximize the amount of possible information from each test or experiment, and thereby increase his ability to make a meaningful and useful analysis of the results. Furthermore, the design techniques can be used in a sequential strategy such that the results of one test can be used as the basis for another test or group of tests if and as required. Thus, larger experimental programs can be planned so that each experiment or test supplements the previous one, enabling the experimenter to proceed in sequential steps as information is gathered. This flexibility allows the experimenter to adjust to unexpected results, good or bad, and thereby increase the chances for success while holding down the overall experimental cost.

The wide range of application and flexibility of statistical experimental design techniques means that they can be used by both industry and private or governmental research institutes, and should be very applicable to developing countries. For they can be applied without the use, for example, of computers or other sophisticated hardware, and experience has proven they can handle complex problems, that is, real practical problems of industrialization.

A related software tool is a continuous investigative routine called Evolutionary Operation, which is applied on the full-scale plant on a day-to-day basis. The philosophy of Evolutionary Operation is that it is inefficient to run an industrial process solely to produce a quality product. That is, a process should be operated not only to produce a quality and reliable product but also to produce information on how to improve the product quality. Evolutionary Operation is a simple statistical method for process improvement, run by the operating people themselves in the normal routine of production. It has successfully been applied in highly industrialized societies, and should have significant potential in developing countries.

The reliability of a product is also one of the major interests of quality control. For, as products become more complex in function and performance, and as the processes for their production become more precise, emphasis on the reliability segment of product quality becomes increasingly significant. Reliability is that aspect of quality assurance which is concerned with the quality of product performance over time. In contrast to traditional quality control, reliability is associated with quality over the long term whereas quality control is associated with the relatively short period of time required for the manufacture of the product. The causes of unreliability of product are many, as are the causes of poor quality.

Product reliability is only one of the qualities of a product, and in the final analysis the reliability requirements for a product are determined by its customers' requirements. There is a certain product reliability standard that provides the customer with the most economical system to meet the required needs, which must be determined as a balance with other product quality parameters. Product reliability is one of the more important qualities of the product, but it should not be separated from other product-quality considerations. At the same time, a consistent upgrading of reliability through a series of effective design changes, method changes, and improved quality control generally provides an economic means for attaining required product reliability goals.

SUMMARY

Systematic quality control and improvement is needed if developing nations are going to benefit from the expanded and improved technologies they are nurturing. Furthermore, all-around quality improvement will be a top problem, and quality problems in general will continue, because the faster the rate of technological progress and the higher the corresponding standard of living, the stricter are the quality requirements for each product and the shorter the time to satisfy the growing demand of a national economy and world markets. Also, it is not a matter of solving the quality problem once and for all, but rather that of keeping the quality of the every product at an up-to-date level, utilizing the latest achievements of science and technology in the production process.

Government backing can assure industrial concentration on quality improvement measures and give powerful impetus to the fuller utilization of proven quality control methodology. It must also strive to foster a quality consciousness among all the people and help create the proper attitude throughout top management. There must be a national policy and capability for standards-setting, or quality control will have a marginal existence if strong mechahisms are not established for enforcing standards, both product and managerial. Hopefully mechanisms can be established which will not be exclusively governmental or purely voluntary. The degree of mandatory means should depend on the unique national character, cultural background and abilities of the developing nation.

The idea of product certification—whereby a product can be made, tested, inspected, and certified in the country of origin to an agreed-upon specification in such a manner that it can be accepted by a local customer or a customer in any other country without further test or inspection—can be used to foster national and international trade. At the same time, certification systems have legal implications in most countries, and they should not become non-tariff barriers but should function as an aid rather than a deterrent to trade. Thus, the goal should be to remove trade barriers, not build them, for the purposes of a quality assurance system are not different from country to country.

A sound quality control system and an effective certification marking program maintains and improves the quality of economically produced products delivered on time. To be effective the programs must be based on technical principles that are true in general, but can be used to custom-tailor the quality programs to fit a given life style and appropriate to unique national needs and goals of improved social, economic, and environmental conditions. At the same time, a national integrity must be the bonding agent between the technological principles and an enhanced quality of life for all, which is the fundamental challenge of increased industrialization.

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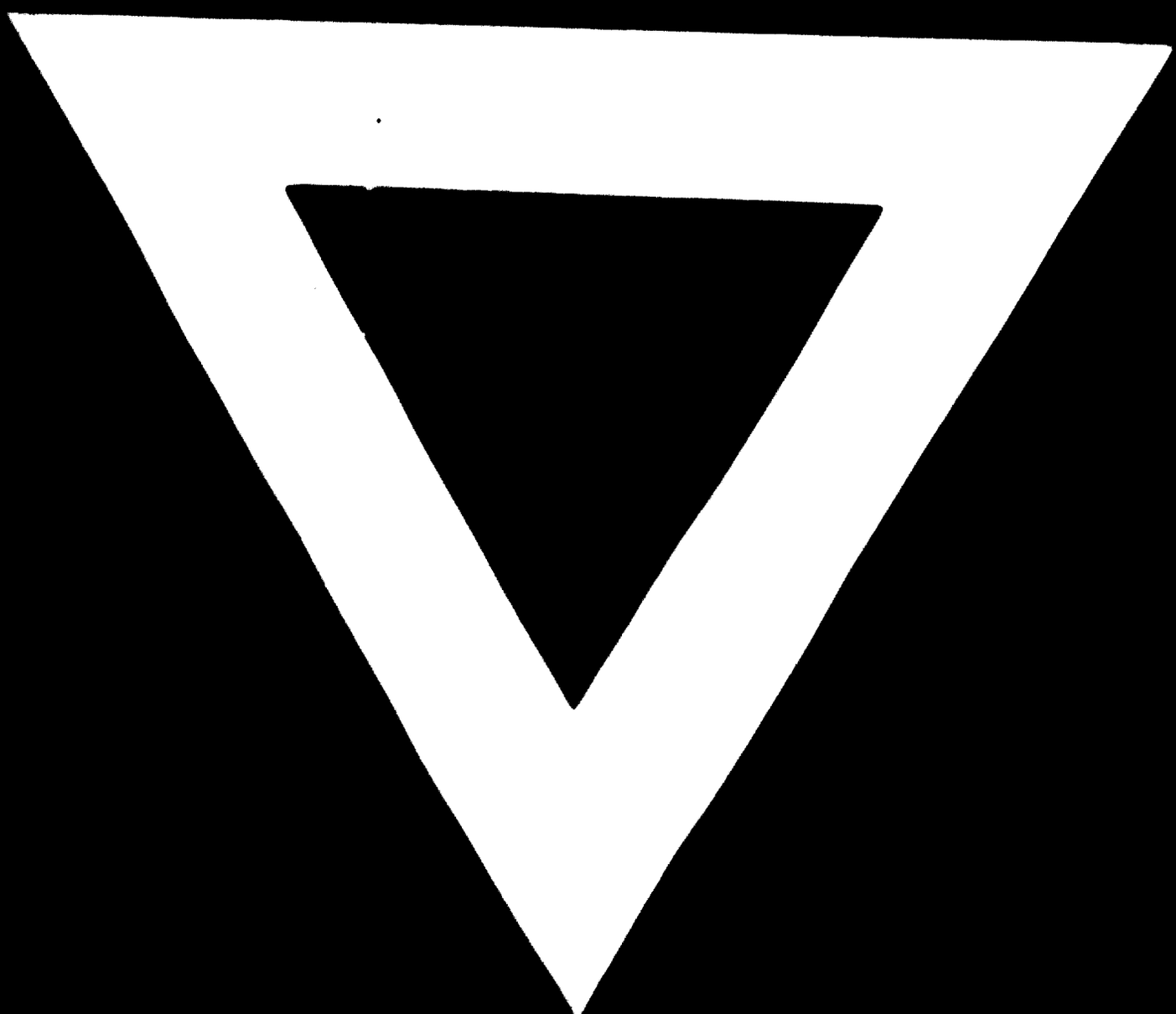

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