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***QUALITY, STANDARDIZATION
AND METROLOGY****

*Prepared by
the UNIDO Secretariat*

* This document has not been edited.

TABLE OF CONTENTS

	Page
I. General Introduction to Quality, Standardization, and Metrology (QSM)	1
II. A Proposed System for Quality and Improvement	2
III. An introduction to the system approach	3
IV. UNIDO's programmes in QSM	5

I. General Introduction to Quality, Standardization, and Metrology (QSM)

The fundamental rules of competitive global manufacturing are changing with the emergence of a new approach to the organization of the firm. This approach has been most closely identified with key aspects of successful Asian manufacturers but is rapidly gaining adherents among manufacturers across the globe. Much of the analysis concerning this development centers on the leading role of quality and quality control. This is because leading manufacturers have been able to establish ever higher levels of product and service quality as sources of major competitive advantage.

Developing countries are rapidly recognizing that quality and its related disciplines figure prominently in strategic national objectives and can help to achieve social and economic progress.

Two other areas which are of prime importance for quality and improvement efforts are metrology and standards. For instance, industrial metrology serves to maintain a system of accurate measurements which are necessary to support the production of quality goods and services. This involves activities such as the careful calibration of machinery and laboratory instruments and greatly aids the quality improvement effort. Standards can play a very important role in the quality improvement effort. A standard is generally any set of requirements to be satisfied by a material, process, product, procedure, test method, and/or physical, functional, performance, or performance characteristic. Currently, the most important quality standard (and the fastest growing standard of all time) is the ISO 9000 Series.

ISO 9000 represents a series of international standards which prescribe acceptable methods to design, implement and assess a quality management and assurance system. This series has been directly linked to the Single Market of the European Union and firms that are certified as having met this standard are able to compete in this market. ISO 9000 is an attempt to standardize a general approach to quality systems at the enterprise level. One factor explaining the rapid success of ISO 9000 is that it brings a degree of order to the market for quality improvement services. Before ISO 9000 there were many different types of "quality programmes" in use. ISO 9000 offers a universal standard which reduces much confusion.

First, ISO 9000 provides the enterprise with a ready set of definitions as to what constitutes quality. Second, clear guidelines are provided for setting up a quality system. Where the enterprise has had little or no experience with quality and improvement, ISO 9000 can provide a solid foundation for subsequent improvement efforts. Moreover, enterprise managers do not have to be convinced of necessary changes in order to attain this certification. This represents a positive development - prior to ISO 9000 many managers displayed cynicism regarding quality improvement programmes.

However, great care should be taken to avoid confusing ISO 9000 standards with an actual system of continuous process and product improvement. ISO 9000 only stipulates that an enterprise should have a documentable quality system - it does not tell management which system to use or how to go about the crucial business of continuous improvement of products and processes. UNIDO can promote the adoption of ISO 9000 at the enterprise level which will help firms gain critical access to markets. But at the same time UNIDO should emphasize that ISO 9000 alone does not ensure competitiveness. It is only a first step on the path to continuous process improvement.

Obviously the role of quality has become a critical variable influencing

an enterprise's competitiveness. However, in the world's most competitive firms increased quality is merely one by-product of an approach that stresses the continuous improvement of all aspects of the production process. Increased product quality - along with a simultaneous stream of advances in productivity, flexibility, and cost performance - occur as a result of a dynamic form of continual improvement of the overall organization.

Continuous improvement is the crucial issue governing competitiveness - and can only take place within a managerial and organizational system which channels all the resources of the firm towards improving products and processes. It is the prime duty of top management to oversee the implementation of a system of total quality management and ensure that it is continually improved upon. This is an important point. Failure on the part of managers to recognize their responsibility for reshaping the organization has led to frequent disappointment with quality improvement programmes. Initially, efforts may yield impressive results - with significant increases in measured quality. However, without a managerial and organizational structure which encourages continuous improvement the firm will find itself falling further behind its more dynamic competitors - despite relative increases in its own levels of quality. This is because the competition has in place a system which generates constant change and innovation in the course of production.

In other cases, an enterprise may vigorously pursue quality improvement only to find sales to be flat or even declining. Analysis often reveals that although product quality increased - it did not reflect characteristics that the customer valued. This is another instance of management's misunderstanding of quality improvement. All quality and improvement programmes must be aimed at increasing customer satisfaction. Comprehensive programmes of "total quality management" or "continuous improvement" should be designed to help managers achieve these capabilities.

II. A Proposed System for Quality and Improvement

In the current global drive to improve quality and production efficiency successful firms have been rewarded with increased market shares. Emerging from this process are new forms of industrial partnership and horizontal integration - as well as new types of financial and accounting tools. While large enterprises have led the way in raising the global competitive standard, small and medium sized enterprises are increasingly seeking increased quality and performance. The rapid rise in applications for ISO 9000 certification reflects the growing demand for services in support of better quality and improvement.

However, much confusion remains in the minds of enterprises managers concerning improvement programmes. An absence of clear quality improvement procedures often worsens the waste of effort and financial resources in many enterprises. Importantly, the lack of adequate performance measurements means that managers often overlook positive results from improvement efforts. While certain outcomes of improved quality may be difficult to measure (e.g. the impact of more satisfied customers), there are many techniques available which can be used to present demonstrable evidence of progress in quality and process improvement. Without such measurements many managers may eventually reject quality and improvement programmes.

The next section offers an integrated approach to quality and process improvement. This combines a system of quality improvement with a set of management tools designed to identify deviations from established goals, and to maximize the use of existing methods by providing a system to measure their effectiveness. New measures are needed to integrate the results of quality

improvement (crucial for customer satisfaction) with measures of efficiency and profitability (a main concern of managers). Such a set of measures will allow managers to quicken the pace of modernization based on existing resources.

III. An introduction to the system approach

The term *system* is frequently used. In principle, a system can be understood as a collection of interacting components. The components of a system include physical forms such as machinery, as well as functional relationships among various physical components of the system. A system can be a nuclear power plant, part of an engine, a process plant for production, a human being or the economic system of a country. In defining a system it is important to establish the boundary which separates the system from its environment. To speak of "controlling" a system means to adjust the outcomes of the system as closely as possible to the performance objectives. This can be done by "feeding back" information from the results of system activities and comparing this with stated goals or objectives. Corrective actions are then taken to reduce the gaps between objectives and actual results. Complex systems may require several different feedback actions in order to be controlled. The system approach provides a comprehensive overview of production performance. In this paper the system under study is the production plant defined as an "enterprise." This is represented in Figure 1.

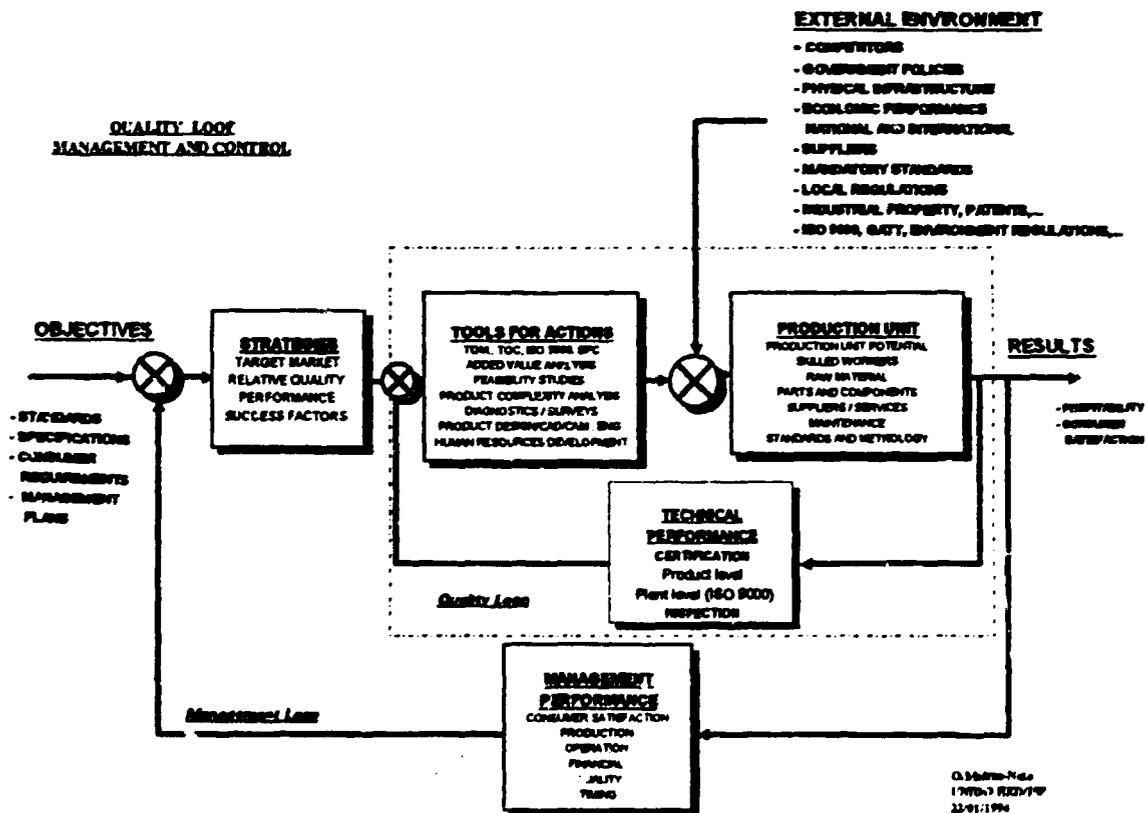


Figure 1 - Graphic representation of the quality system approach

This system is comprised of two major parts: an inner quality loop and an outer management loop. The inner quality loop, shown in gray highlights, involves the main activities that are responsible for compliance with specifications and the creation of consumer satisfaction. The management loop is responsible for the operational performance of the enterprise. Here objectives and strategies must be well defined and supported by accurate data.

Without such information effective planning and strategy formulation will be difficult. The external environment is beyond the control of the production system.

The control of the production process can be achieved with the use of powerful analytical tools such as statistical process control (SPC). SPC comprises an indispensable set of tools used to control deviations from established specifications in the production process. However, within the management loop traditional accounting tools are often the only performance measurements used. Standard accounting practices can overlook the critical role played by product and processes improvements and may lead managers to undertake actions that can actually worsen quality within the enterprise. Along with the initial implementation of tools such as SPC the quality loop can be strengthened through the introduction of inspections designed to detect deviations from specifications and to identify production non-conformities. As deviations are reduced (through the use of SPC) so will the need for inspections. At this stage many types of improvements at the plant level can be undertaken by managers.

Managers and workers can join together in an effort to improve the products and the production process. As defects, rework, and waste are all reduced motivation and profitability will improve. At this point the implementation of product certification can be used to highlight the technical characteristics of the product. Additionally, ISO 9000 can provide incentives for the continuous improvement of quality and consumer satisfaction by requiring managers to document a system of good production practices.

In the next stage it is necessary to build up the outer feedback loop (management loop) which includes different types of instruments used to measure the state of the system. As mentioned, standard accounting methods only provide a narrow picture of enterprise performance. To improve the performance evaluation of the enterprise new instruments have to be defined and implemented. Operational and financial metrics must be complemented by those which measure consumer satisfaction.

The results of this performance evaluation shall be compared with the objectives of the enterprise (standards, specifications, consumer requirements, management goals and plans, etc.) to further refine strategic decisions. The basic assumption of the system approach presented in Figure 1 is that when objective measurements of performance are tied to profitability and customer satisfaction entrepreneurs will need no further proof of the importance of continuous improvement.

Each box in Figure 1 indicates commonly used tools and methods in the operation of the enterprise. Naturally, the number and the complexity of the components within production systems vary widely. The systems in many small and medium enterprises can be controlled using a few relatively simple improvement tools and methods. Large enterprises require a substantial amount of effort and resources to achieve and maintain control. Further, they must optimize their production time constant to maintain competitive lead times.

Control strategies will only be effective if measurements provide enough information to support appropriate actions. This means that the *instruments* used to measure the performance of the enterprise have to be quick and reliable.

Two basic instruments have been developed by UNIDO for this purpose: a short-medium term measurement reflecting the difference between planned and actual performance and a medium-long term measurements to present the accumulated performance.

These two instruments are implemented through software toolkits. The first one - BEST (Business Environment Strategic Toolkit) - is a set of user friendly software modules designed to both teach entrepreneurs production planning and to support strategic decisions. The main modules are the Operation Management Assistance, the Strategic Management Assistance, the Investment Assistance and the Product Monitoring Assistance. BEST is not a traditional accounting system -but a comprehensive operational tool for managers. Operating indicators are used to monitor performance, productivity and utilization of facilities.

The second instrument - FIT (Financial Improvement Toolkit) - is a management support tool to aid in operational and strategic decision making. A group of important indicators are calculated and their evolution over time is displayed. These indicators are used to strategically position the business and to point to potential operational problem areas. This tool can analyze an entire enterprise, or specific strategic business units (SBU - consist of well defined products or services which are targeted at specific market segments) within an enterprise.

These software tools can provide entrepreneurs invaluable insight into their enterprise's operational performance. The results are presented in graphical form comparing monthly planned versus actual performance.

IV - UNIDO's programmes in QSM

UNIDO's activities in the field of QSM started in the 1970's with an emphasis on standardization and metrology. Over a period of two decades projects have been implemented in all continents for the establishment of standardization bodies and national metrology laboratories. From 1989 to 1993, over 75 projects representing more than US\$ 40 million were implemented. Minor assistance has also been offered to assess national institutions in product certification.

In 1987, the ISO (International Organization for Standardization) issued the ISO 9000 series which has become the most rapidly growing standard of all time. The rate of growth in applications for ISO 9000 certification ensure that much quality improvement activity will center around this important standard through the end of the century. As mentioned, ISO 9000 is not the same as a system of continuous improvement - but can serve as an important catalyst for generating sustained increases in enterprise performance. UNIDO is currently designing new types of assistance aimed at promoting the ISO 9000 along with TQM and continuous improvement. In this context the above mentioned approach is being developed and implemented with great success in Argentina, Bolivia, Brazil, Chile, Colombia, Cuba, Ecuador, Mexico, Peru and Venezuela under a regional programme for the modernization of the capital goods sector. Other potential areas for development are assistance to national standardization bodies - or NGOs for acquiring assessment capability for ISO 9000 certification.

The reoriented programme of UNIDO in QSM also deals with certain specialized "core" products. UNIDO services can be provided for different levels outlined below on request from member-states, and subject to availability of funds.

Policy level

- Assist Governments in the establishment of quality, standardization and metrology policies

- Assist Governments in the establishment of ISO 9000 certification bodies

Institutional level

- Assist metrology bodies in up-grading the existent reference standards and procedures
- Assist national organizations in the establishment of sectoral laboratories
- Build capacity to assist enterprises in the application of the broad range of quality tools using a systems approach for quality improvement

enterprise level

- Establishment of specialized laboratories
- Assistance to implement the system approach for quality improvement

In the future the commitment of enterprise managers will be necessary to guarantee the ongoing success of UNIDO programmes in QSM. In the early stages of improvement managers will be faced with the rigid requirements imposed by ISO 9000. At this point it is equally critical that the manager be convinced of the need to measure enterprise performance and begin a programme of continuous improvement. Therefore, the system approach represents an effective way to combine both robust technical assistance in QSM and pragmatic improvement efforts.

UNIDO's Core products

The system approach described above offers an objective way to measure system performance and can serve as an overall methodology which can promote linkages across various QSM projects in UNIDO. The approach was first applied in 1993 in the regional programme of capital goods sector in Latin America and Caribbean countries and is presently being initiated in a national execution project in Tunisia. Below are presented some proposed core products which increase UNIDO's participation and impact in the rapidly growing area of QSM.

a) *BEYOND ISO 9000 or UNIDO ISO 9000" approach*

ISO 9000 has now become necessary to help firms enter foreign markets. However, it is not sufficient to guarantee their sustained success. An ISO 9000 Certificate does not guarantee a product's quality nor the capabilities of managers. To achieve sustainable market performance the enterprise must go beyond ISO 9000 and implement a comprehensive system that will generate continuous improvements in quality, cost and flexibility. Increased quality is one by-product of an approach that stresses continual improvement at all the steps of the production process. The crucial issue determining competitive success is the ability of managers to create a production system that channels all the resources of the enterprises towards improving products and processes.

Companies seeking for the ISO 9000 certification must be concerned with strategies that should go beyond it and include:

- programmes for implementation of Total Quality Management Systems and continuous improvement of the overall production process from product design to customer delivery
- implementation of user friendly and precise instruments for

measuring the technical as well as the managerial performance of the enterprise.

Experience gathered through the implementation of a series of projects for promoting quality improvement and ISO 9000 certification has provided the basis for the above mentioned approach. This approach does not limit itself to ISO 9000 certification - but aims at creating a sustainable basis for the continuous improvement of process and product quality. In addition, this strategy aims to disseminate methods and instruments to managers that can provide valuable insight into the competitive strengths and weaknesses of their enterprises. While the limitations of ISO 9000 are recognized, the heavy demand for certification represents a good reason for UNIDO to intensify the assistance for developing countries for quality improvement services. This recently developed approach is currently being successfully used in over 90 enterprises in Latin America and the Caribbean.

The UNIDO ISO 9000** is based on the system approach described above and includes, among others components for strengthening continuous improvement capabilities, implementation of Total Quality Management in enterprises, application of Statistical Process Control, preparation for ISO 9000 certification, ISO 9000 diagnostic at plant level, assessment methodologies for product certification, continuous operational performance evaluation, computerized production and business performance evaluation, strengthening strategic planning and decision making capabilities.

UNIDO ISO 9000** service could support activities at three major levels:

- Institution Building: Building capacity at the level of national organizations (industry associations, R&D institutions, consulting companies, etc.) to be used for assisting enterprises in implementing quality systems, and management and control based on ISO 9000;
- groups of enterprises: Cost effective implementation of the procedures required for certification in ISO 9000
- Individual enterprises: in implementing total quality management programmes and practices for continuous improvement, assessing conditions for ISO 9000 certification and implementing corrective actions

b) *Assessment and support for the establishment of ISO 9000 certification bodies*

ISO 9000 certification increasingly represents a commonly accepted "seal of approval" for a firm to act as a sub-contractor or to export to large parts of the world. A recent ISO publication (ISO 9000 News, January 1994) indicates that out of the 45,000 total certificates issued through 1993 only 0.7 percent were issued in developing countries - for a total of 3.5 certificates.

It is likely that this figure represents only those certificates issued by the most important assessment bodies from developed countries to enterprises in developing countries. A critical point is that national assessment bodies in developing countries do not have the credibility to be accepted around the world. Without mutual recognition of assessment bodies, standards such as ISO 9000 are likely to represent significant non-tariff

barriers to trade in coming years.

With these important developments in mind a new UNIDO product is under development to assist Governments in the establishment of national assessment for ISO 9000 certification of local enterprises.

The product will be implemented at selected groups of enterprises seeking ISO 9000 certification in the country and will comprise support to local authorities in the selection of the national assessment body, application of ISO 9000 procedures to the selected group of enterprises to be initiated by international experts who will then prepare the national teams, establishment of all required procedures and paper work at the selected institution and search for cooperation with assessment bodies from developed countries for the purpose of mutual recognition.

c) *Centres for Productivity and Quality*

Another effective approach is to establish permanent centres dedicated to training managers, technicians and workers in the application of various improvement practices such as statistical process control. These could be based at a university, technical institute, or industry association facility. UNIDO is currently assisting in the creation of such centres in Brazil and Hungary. They can be staffed by full or part-time faculty with plant-level experience in applied methods of quality control and continuous improvement. Training sessions and seminars should also include quality and improvement of professionals from multinational firms as well as their national counterparts. Government support is required in the start-up phase. However, these centres are ultimately expected to be self-financing (usually within three years) through funds obtained from trade and industry associations and chambers of commerce, as well as fees paid by individual firms.

A permanent institution avoids some of the pitfalls commonly encountered with other methods for training and application. First, they will generally be cheaper than consultants and their training more appropriate than offered by universities. Second, consulting firms that tend to specialize in a limited range of improvement techniques while the appropriate mix depends on the products and processes of the firm and will change over time. A permanent centre is better able to meet these varied and changing needs. Third, assistance from consultants is almost always limited in duration, although the transition from a beginning practitioner to a continuous improvement firm takes many years. Fourth, a permanent centre is better prepared to advise on many of the strategic issues of continuous improvement which are of a long-term character and link suppliers with their customers. Finally, these centres can afford to take a very practical approach to improvement problems while universities (and sometimes consultants) emphasize theoretical aspects rather than applications.

d) *Rehabilitation of metrology laboratories*

Metrology is the science of measurement with the principal goal of creating and maintaining the uniformity of measurements in any required human activity. Metrology consists of three main parts, in particular: scientific, industrial and legal metrology.

Scientific metrology deals with the development and maintenance of national primary, reference and working standards and traceability of units of physical quantities from standards to working instruments.

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Scientific metrology deals with the development and maintenance of national primary, reference and working standards and traceability of units of physical quantities from standards to working instruments.

Industrial metrology deals with calibration and testing services to industry.

Legal metrology deals with legal and regulatory control in relation to units of measurements, methods of measurements and measuring instruments.

To implement its goal in the creation and maintenance of national and reference standards, as well as in providing traceability to industry, a metrology system or metrology tree is a national infrastructure which has been created in developed countries and should be established in developing countries. It starts from the national standards maintained by the national laboratories, continues with the national network of calibration laboratories, goes to the reference standards of industrial companies and testing laboratories. In this tree, some elements are essential:

- the national metrology standards which comply with the SI units (international system)
- the national laboratories which maintain the National standards and disseminate the units
- the calibration laboratories.

The objective of the Rehabilitation of metrology laboratories is to improve or create credible capacity at regional, national and sectoral levels to enable the national system to provide traceability in measurements at any level with confidence to domestic and foreign customers.

The objective of the assistance will be achieved through evaluation of existing structures and available facilities by a UNIDO's staff member/international expert, identification of the major changes to be taken by the national institutions to overcome discrepancies, and implementation of the required actions to achieve the objectives of the assistance through utilization of national/international expertise and of additional/new equipment.

Special considerations

The core products described above are usually considered necessary to support countries in improving the quality of their goods and increasing the potential of enterprises to compete with foreign products. The costs of UNIDO assistance would vary from case to case, depending on the UNIDO's services considered necessary. Core products like "Beyond ISO 9000" or assessment for certification may be estimated at the rate of US\$ 3,000 to US\$ 5,000 per enterprise per year, over a period of time, for groups comprising 20 enterprises. As far as funding is concerned the core products are specially suited for self financing by the enterprises and cost shared by specialized funding agencies or donor countries.

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