ENVIRONMENTAL MANAGEMENT STANDARDS (ISO 14000): TOWARDS A SUSTAINABLE FUTURE

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UNEP

Universiti Putra Malaysia Press
Serdang • 1999

UPM Press is a member of the Malaysian Book Publishers Association (MABOPA).
Membership No. : 9802

Perpustakaan Negara Malaysia   Cataloguing-in-Publication Data

Environmental management standards (ISO 14000): towards
a sustainable future / the editorial board Muhamad Awang
... [et al.].
ISBN 983-9319-54-X
ISBN 983-9319-53-1 (pbk.)
1. Environmental protection–Standards–Malaysia.
I. Muhamad Awang.
658.4080218595

Universiti Putra Malaysia Press
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Typeface: Adobe Garamond Regular
Type Size: 12/14

This publication has been produced with support provided by the **Danish Cooperation on Environment and Development (DANCED)** and the **United Nations Environment Programme** (UNEP). The preparation of this document was carried out under project Training for the Implementation of Environmental Management in Accordance with Emerging Best Practices in Industry CP/5220-97-01, which was implemented within the framework of the Network for Environmental Training at Tertiary Level in Asia and the Pacific (NETTLAP).

PREFACE

Although environmental problems of industrial origin are long-standing, attempts to deal with them in developing countries are relatively recent. As Malaysians and members of the global community, we incessantly strive for long-term economic growth that creates jobs while improving and sustaining a clean and healthy environment. Realising these goals requires environmental management strategies and technologies that address the need to remediate past environmental damage while helping us shift emphasis from waste management practices to pollution prevention and more efficient use of valuable resources. The development and implementation of new concepts of environmental management standards, in particular the ISO 14000 series, are emerging as important tools within an organization's overall management systems geared towards realizing these intentions.

ISO 14000 is a new series of environmental management standards that provides organizations with guidance on setting up environmental management systems that can be integrated with other management functions to assist organizations achieve satisfactory environmental and economic performance. The ISO 14000 standards were developed as a result of two events: the Uruguay Round of multilateral trade negotiations under the General Agreement on Tariffs and Trade (GATT), and the United Nations Conference on Environment and Development in Rio de Janeiro in 1992. While GATT worked to remove technical barriers to trade, the UN Conference helped gain the commitment of the global community to the protection of the environment. The ISO 14000 series is expected to help bridge the twin objectives of protecting the environment while expanding the world economy. A comprehensive and effective environmental management system can assist a company to manage, measure, and improve the environmental aspects of its operations. It can lead to more efficient compliance with mandatory regulatory and voluntary environmental requirements and help companies to incorporate environmental management practices into their overall business operations. In short, the working philosophy in the development of ISO 14000 standards can be stated as

> Better environmental management will lead to better environmental performance, increased efficiency, and greater returns on investment.

The ISO 14000 standards have been described as the new global passport for international trade. Businesses of all sizes will need to face the fact that it is expected to become the *de facto* international standard for proactive environmental management practices and a requirement for conducting international trade and businesses. Hence, there are two major reasons for organizations to adopt the ISO 14000 standards:

- To ensure continued access to global markets and customers who require conformance to the standard as a condition of business.

- To respont to increasing interest of regulators in adopting the ISO 14001 environmental management systems standards in regulatory reform initiatives throughout the world.

Although it may be too early to predict how the practices advocated by ISO 14000 will accomplish the two goals of expanding the global economy while ensuring compliance with environmental management standards, the ISO 14000 standards will make environmental implications of industrial processes and technologies more transparent, and will promote ecological efficiency, the transfer of environmentally sound and clean technologies. Even though increased environmental performance may not be so apparent at this moment in time, the tools needed and the path that we need to travel towards sustainable practices are laid down by the ISO 14000 standards.

The Malaysian government has expressed a keen interest in encouraging industries to adopt a systems approach towards environmental pollution control and management by incorporating provisions for auditing of environmental management systems in the 1996 EQA Amendment. Malaysia has also, through the Standards and Industrial Research Institute of Malaysia Berhad (SIRIM), adopted in December of 1995 the first of the ISO 14000 series as the provisional (P) Malaysian Standard (MS). Preparations to implement environmental management systems will undoubtedly present new challenges as well as golden opportunities for many. Obviously, organizations must familiarise themselves with these environmental management tools. In addition, government officials and public sector policy makers, especially those involved in industry, technology and trade matters, should begin to take appropriate action. Unfortunately, there is not much guidance available to assist government and private organizations - in particular the small and medium scale industries - to utilise these environmental management tools effectively. The shift to more cost effective, competitive and more environmentally responsible methods of production requires a deeper understanding of the entire production process and of the technologies involved. As the capacity for handling management issues has become a key requirement, a more sophisticated education and training of firm managers, engineers and other senior staff involved in the creation of technological innovations is needed to understand the links with technology performance, competitiveness and environmental benefits.

Universiti Putra Malaysia has developed a training program for the implementation of environmental management in accordance with emerging best practices in industries. This training program is being implemented within the framework of UNEP's Network for Environmental Training at Tertiary Level in Asia and the Pacific (NETTLAP) and the Malaysian Inter-University Network for Training and Research on Environmental Management (MATREM). This book has been prepared simultaneously with a series of training modules and manuals for the ISO 14000 standards on environmental management. The successful creation of the book was the outcome of a joint effort of those at Universiti Putra Malaysia (UPM), the National Committee on Environmental Standards (NACES), United Nations Environment Programme (UNEP) and the Danish Cooperation for Environment and Development (DANCED). This book is written with the hope that it will constitute the basis for the dissemination of information on the ISO 14000 series of standards in Malaysia and chart the path needed to make our way forward towards a sustainable future.

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ACKNOWLEDGEMENTS

We would like to gratefully acknowledge the contributions of the following people and organizations towards the development of this book:

Prof. Tan Sri Dato' Dr. Syed Jalaludin Syed Salim, Vice-Chancellor of Universiti Putra Malaysia (UPM); Dato' Dr. Abu Bakar Jaafar, Chairman of the SIRIM Industry Standards Committee on the Environment (ISCZ); Dr. Suvit Yodmani, Regional Director and Representative of the United Nations Environmental Programme/Regional Office for Asia and Pacific (UNEP/ROAP); Prof. Dr. Muhamad Awang, Chairman of the Malaysian Teaching and Research on Environmental Management (MATREM) and the Malaysian Focal Point Network for Environmental Training at Tertiary Level in Asia and the Pacific (NETTLAP); Dr. Ramdzani Abdullah, Head of Department of Environmental Science, UPM; Assoc. Prof. Dr. Mohd. Ismail Yaziz, Department of Environmental Science, UPM, members of the MATREM Steering Group; Dr. Sudhin Yoosook, Project Co-ordinator of Training and Research on Environmental Management (TREM); Mahesh Pradhan, Environmental Affairs Officer and NETTLAP officer for UNEP/ROAP; Dr. Thamnoon Rochanaburanon and Dr. Supachit Manopimoke, previous TREM Co-ordinators; Prof. Dr. Mohd. Nordin Hj. Hassan, MATREM Project Coordinator, UKM; Ooi Diang Ling and Ole Flying, DANCED representatives in Malaysia and last but not least, Mogens Dyhr-Nielsen, the DANCED Program Director in Denmark.

We would also like to extend our heartfelt and sincere thanks to the technical and support staff of the Centre for Environmental Technology and Natural Resource Management, UPM for their enthusiasm, perseverance, patience and thoughtful guidance - in particular, Mazni Abdul Hamid, Mazniah Mohd. Yusoff, Mazaida Ali, Mazlina Abdullah, Mohd. Azahan Alias, Ruslan Riffin, and Mohd. Nizam Lani.

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1 INTRODUCTION

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Recent developments in the ISO 14000 series of standards have provided new opportunities and challenges to both government and industry world-wide. Since 1995, due to the outcomes of the drafting and approval of the ISO 14001 environmental management system (EMS) specification, countries and organisations world-wide have been performing assessments and conducting pilot trials to prepare to conform to the standard. The prime motivation for seeking conformance varies with the implementers. Governments are interested in the ISO 14001 EMS standard as it offers an alternative approach to the traditional command-and-control regulatory model that is increasingly seen by critics as expensive and inefficient. Adherence to the standard is regarded as providing an opportunity to develop an effective EMS that can demonstrate a reasonable standard of environmental care. For industries and business organizations, conformance is considered firstly for continued access to markets and customers who require conformance to the standard as a binding business requirement, and secondly in the interest of regulators who adopt the standard for regulatory reform initiatives. Hence, the standard has been described as the new global passport for international trade.

The proliferation of the international standard proves the global community's commitment to sustainable development. The standard aims to facilitate international trade by harmonising multiple environmental standards in different markets and by integrating environmental protection with business activities. The standard will be a means of making countries realise that the environment is not only a crucial economic resource but an integral part of the development process, and that its degradation entails both direct and indirect consequences. However, the disparity that exists between the capacities of the developed and developing countries will pose challenges to a widespread adoption of the standard. Developing countries are not always in a position to conform to the standard since they suffer from inadequate environmental regimes which are usually the result of poverty, insufficient policy making and inefficient technological capacity, lack of timely access to relevant information, and limited resources. Some countries also lack the political structure and public support necessary to generate demand for such standards. Hence, in some places, the ISO 14001 standard is seen as putting up a potential barrier to trade. Although conformance to the standards is voluntary, wide acceptance of the standard will most likely make the marketplace or governments demand third-party certification. If the standards become a requirement for doing business in the international and domestic marketplace, it will raise a number of concerns mainly regarding its implications on industries of all sizes and trade of developing countries. It was suggested that the impact of ISO 14000 series of standards will be significant for businesses exporting to global markets and their suppliers; preparing for ISO 14000 today is no longer an option, but a matter of survival in the market.

The developments in the international arena regarding the ISO 14000 standards have serious implications for the SMIs (small and medium size industries) in Malaysia especially those SMIs that are export oriented or those attached to multinational companies who are most definitely conforming to the standards in order to maintain international market competitiveness. Factors that determine local competitiveness may soon include environmental management aspects when the use of ISO standards proliferates and is accepted by governments and industries world-wide and in Malaysia. The current state of the SMIs in Malaysia will place them at an extreme disadvantage as they do not practise sound environmental management and lack the resources and capacities to develop and implement an environmental management system (EMS) and conform to the ISO 14001 EMS standard. SMIs, in both developed and developing countries tend to face greater difficulties in developing an EMS. In addition, development of an environmental management system in developing countries is more costly. It is expected that non-compliance to the ISO standard by the Malaysian SMIs will not only effect the SMIs' business but also the national economy.

In order to face the new challenges and opportunities brought about by the ISO 14000 series of standards, it is crucial that the Malaysian community come to recognize and understand their potential implications. Local and foreign experts on the standards have joined together to produce this new book. This book is a compilation of essays on a wide array of topics and pressing issues required to successfully understand, initiate, and implement an ISO 14000 program. The chapters have been prepared with the objective of providing basic knowledge on the ISO 14000 series of standards. Our experts have provided timely insights, case studies and essential guidelines to help organizations improve their environmental performance. The information and knowledge contained herein will power up the engine needed to move forward towards a sustainable future.

Chapter 2 of the book provides an overview of the ISO 14000 series of standards and their impacts on the environment and business operations. Chapter 3 gives details of the history, development and organization of the ISO standards. Chapter 4 presents the ISO standard that concentrates on harmonization of the terms and definitions used within the ISO 14000 standards. Chapters 5 and 6 provide the most important and basic information needed for the implementation of the ISO 14000 series of standards, that is, the ISO 14001 Environmental Management Standard. Chapter 7 gives guidelines and information on how an environmental management system can be audited. Chapter 8 provides information on organizational evaluation by the ISO 14000 standard called environmental performance evaluation. Chapters 9 to 13 concentrate on the ISO standards that evaluate product performance which include life cycle assessment, environmental labeling, design for the environment and environmental aspects in product standards. The chapter concluding the book discusses the potential barriers that hinder ISO 14000 development and implementation in Malaysia and the strategies that can be undertaken to eliminate the barriers.

The editors would like to thank all the contributors who have generously given time to prepare these chapters. Our numerous discussions have helped bring forward what we view to be the information that will be most useful to Malaysian organizations in their efforts to make the best of their ISO 14000 program initiatives and navigate towards sustainable practices.

2 THE ISO 14000 SERIES AND ITS IMPACT ON THE ENVIRONMENT AND BUSINESS

KUN MO LEE

INTRODUCTION

The environmental problems we have today have expanded from local and regional ones to global ones. Resource consumption as well as environmental emissions originating from industrial activities pose serious threats to human health and to the stability of ecosystems.

It is a well known fact that the global environmental carrying capacity has its limits. Natural resources including mineral ores and fossil fuels, agricultural productivity, and self-purification capacity of the natural environment have their own limits. Irrational resource consumption together with irresponsible environmental pollution resulting from the entire product life cycle - raw material acquisition, manufacturing, use and disposal — are the main causes of exceeding the global environmental carrying capacity. This is because our industrial structure and consumption pattern are not environment friendly. Thus, there is a growing concern that sustainable society may not be achievable.

Industry is the single most important source of all these environmental problems. This is because human society depends heavily on industrial products to sustain its living standard. Corporations consume resources and create during environmental emissions during product manufacture stage. These are, however, not significant compared to that a product generates during its life cycle. In general, environmental load throughout the entire life cycle of a product is much greater than that from the manufacturing stage. A typical example would include durable goods such as home appliances and automobiles. Environmental loads from the use and disposal stages are much greater than that from the manufacturing stage. For goods like paper towels and aluminum foil, environmental load from the manufacturing stage is relatively high; however, the total load is still greater than that from the manufacturing stage. From the discussion, it can be concluded that environmental loads occurring throughout a product life cycle is the main cause of today's environmental problems.

Traditionally, environmental laws and regulations have aimed at commanding and controlling the environmental load occurring during the manufacturing stage of a product. In other words, the command and control were centered on the end-of-pipe treatment. Sincere efforts have been exerted in implementing the command and control practices in most of the developed nations although they are burdensome to most corporations. However, the global environment problems have not been mitigated: rather, they tend to be aggravated.

Since 1990, environmental policy makers in the Netherlands and Germany have recognized that packaging wastes may be reduced in quantity by imposing a financial burden on the producer, not on the consumer. This is the basis of the concept of the extended producer responsibility (EPR) (OECD, 1996). The norm was that manufacturers were responsible for the product only during its manufacturing stages (e.g. product function, production cost and environmental pollution control, etc.). They were not responsible for the environmental problems caused by the waste product discarded after use. Collection, treatment and disposal of the waste products were the responsibility of the government and local authorities. However, under EPR, the cost associated with the waste product's collection, treatment and disposal should be borne by the manufacturer. Typical regulations based on the EPR concept include the packaging waste order in Germany, the packaging covenant in the Netherlands, and voluntary agreement on cost bearing of waste automobile treatment among German auto makers.

In response to the apparent failure of the command and control policies, the emerging EPR policy and growing pressure from the public, industries decided to take the initiative in overcoming the environmental problems rather than being pushed by the interested parties such as governments, environmental activists and the public. The initiative was the introduction of a voluntary program called environmental management into the management of corporations.

Environmental management, first introduced in the Netherlands in the early 1980s, aimed at implementing environmental management of a corporation by setting environmental policy and identifying significant environmental aspects of a corporation by (1) taking into account suppliers and consumers (2) preparing the environmental and operational programs, (3) measuring and monitoring the environmental performance, (4) auditing the environmental performance, and (5) reviewing the overall environmental management. These voluntary measures were acceptable to the government because environmental management considers not only the manufacturing stage but also the entire life cycle of a product. Furthermore, it strives for pollution prevention rather than end-of-pipe treatment. The government in return gave leeway to industries by relaxing some of its command and control regulations. To ensure proper implementation of environmental management, environmental auditing of the corporation's environmental management by an independent third party was also required. After all, the introduction of environmental management to the corporation's management system was mutually beneficial to both industry and government.

The environmental management practice has evolved into a system called environmental management systems (EMS). The EMS quickly spread among various organizations in developed countries, mainly the UK, the Netherlands, and the Nordic countries, especially among multinational corporations. As a result of proliferation of EMS together with other environmental requirements for the management of corporations' environmental issues, there emerged a necessity for standardization of these environmental practices.

The Business Council for Sustainable Development had made a request for the standardization of the environmental management practices to the United Nations

Committee on Environment and Development, which in turn passed the request to the International Organization for Standardization (ISO) in April 1991. In October 1991, ISO formed the Strategic Advisory Group on Environment to evaluate the necessity of standardization for EMS. After one year of study, they recommended that ISO should standardize the EMS. As a result, Technical Committees (TC) 207 were formed in June 1993 to standardize the EMS. The resulting documents are the ISO 14000 series.

A major driving force for the standardization of the ISO 14000 series is a desire for international standards on environmental management, environmental labeling, environmental performance evaluation (EPE), and life cycle assessment (LCA). There was a strong need for international harmony in developing environmental standards to deal with the environmental issues in the coming 21st century, called the century of environment.

The first ISO 14000 series standard was published in September 1, 1996. It is the standard on EMS and its document number is ISO 14001. A guide document for the use of ISO 14001 was also published at the same time. This is ISO 14004. In October 1, 1996, ISO 14010, 14011, and 14012, which deal with auditing of the EMS, were published. Standards on environmental labels and declarations (EL) and on EPE are expected to be published soon. One LCA standard was published (ISO 14040) and others are in preparation. Figure 1 lists the document number and status of each ISO 14000 series standard.

ISO standards are voluntary in nature; thus, there is no legal obligation to comply with them. However, once these ISO standards are adopted as regulations in a nation or become requirements in trade, they become mandatory requirements. Accordingly, participating countries in the TC 207 meetings do their best to represent their viewpoints and interest in the ISO 14000 series.

The most effective way for any organization to deal with global environmental regulations is to adopt environmental management. The ISO 14000 series are recognized as guide documents worldwide for the environmental management of an organization. Therefore in depth analysis of the ISO 14000 series in terms of content, applications and implications is a prerequisite for any organization wishing to manage the organization in an environmentally friendly mode. The key to environmental management, of course, is a firm conviction that environmental management is a vital tool for the survival of the organization in the 21st century. Following is a synopsis of each standard of the ISO 14000 series.

THE ISO 14000 SERIES

EMS and EA

A diverse form of EMS has been implemented in various organizations including private corporations in developed nations. Countries such as the UK, the Netherlands, the Nordic countries, France and Japan are the most active in developing and implementing EMS.

The prime objective of implementing an EMS is to improve the organization's environmental performance continuously. Benefits of successful implementation of an EMS would include

TASK GROUP	DOCUMENT NUMBER	TITLE	PUBLICATION DATE
SC1 WG1	14001	Environmental Management Systems - Specification with Guidance for Use	96. 9.1
SC1WG2	14004	Environmental Management Systems - General Guidelines on Principles, Systems and Supporting Techniques	
SC2 WG1	14010	Guidelines for Environmental Auditing - General Principles on Environmental Auditing	96.10.1
SC2 WG2	14011	Guidelines for Environmental Auditing - Audit Procedures - Auditing of Environmental Management Systems	
SC2 WG3	14012	Guidelines for Environmental Auditing - Qualification Criteria for Environmental Auditors	
SC3 WG3	14020	Environmental Labels and Declarations - General Principles	Late 1998 (expected)
SC3 WG2	14021	Environmental Labels and Declarations - Self Declaration Environmental Claims - Guidelines, Definitions and Usage of Terms	Mid 1999 (expected)
SC3 WG1	14024	Environmental Labels and Declarations - Environmental Labelling Practitioner Programs, Type I, Guiding Principles and Procedures	Late 1998 (expected)
SC4 WGs1/2	14031	Environmental Management - Environmental Performance Evaluation - Guidelines	Late 1999 (expected)
SC5 WG1	14040	Life Cycle Assessment - Principles and Guidelines	97.6.15
SC5 WGs2-3	14041	Life Cycle Assessment Life Cycle Inventory Analysis	Late 1998 (expected)
SC5 WG4	14042	Life Cycle Assessment- Impact Assessment	Mid-1999 (expected)
SC5 WG5	14043	Life Cycle Assessment - Interpretation	

Figure 1. Current status of the ISO 14000 series documents

reduced cost in pollution prevention activities, compliance with regulatory requirements, and a better organizational image, among others. However, these diverse EMS frameworks have the potential of becoming technical barriers to international trade. This very fact became the fundamental driving force for the standardization of not only the EMS framework but also other EMS related tools.

ISO 14001 specifies requirements for an organization in implementing an EMS. The organization wishing to implement an EMS shall establish the environmental policies, objectives, and targets. After implementing these activities, the results of the implementation are checked and reviewed. Then policies, objectives and targets are renewed or modified as needed. The continuous cycle of these activities will lead to continuous environmental improvement. Continuous environmental improvement is one of the key concepts of ISO 14001. The other is pollution prevention (ISO 14001, 1996).

The significance of documentation of the management system has been valued highly in ISO 9001. The same is true in ISO 14001. However, too much emphasis on documentation may overlook the fundamental philosophy of ISO 14001. The priority of implementing ISO 14001 is always to achieve real environmental improvement, not to have a nicely documented EMS framework only.

To achieve environmental improvement effectively and efficiently, the first thing to do is to identify key environmental issues of the corporation's products or services throughout the entire life cycle. This can best be done by using LCA, either screening or streamlined, or mere life cycle considerations. Some key environmental issues may be controlled by the organization, but some are not. ISO 14001 specifies that environmental objectives shall be established based on controllable key environmental issues (ISO 14001, 1996). The implementation of the environmental objectives requires resources such as personnel and finance, and technologies. Thus, a list of priorities for the environmental objectives should be prepared considering practical constraints.

Targets which are measurable shall be established to achieve environmental objectives and the EMS is implemented, as stated above in a cyclic fashion. Suppose the environmental objectives are established rather arbitrarily, there is the possibility that these objectives may not be the key environmental issues. Since resources are expended to achieve the objectives, ill-fated objectives could result in losses to the organization. Improper objectives lead to improper investment which results not only in financial loss, but also in no environmental improvement. Consequently, a proper evaluation of environmental aspects and proper selection of the environmental objectives are crucial elements to the success of EMS implementation.

Since the publication of ISO 14001 in September 1996, the number of organizations certified under ISO 14001 has been increasing. Table 1 shows the number of certificates issued in Asian countries (AIIN, 1998). Table 1 indicates that ISO 14001 is gaining wider acceptance globally and will become a norm in environmental management in the near future.

Table 1. Number of Certificates Issued in Asian Countries (as of June, 1998)

COUNTRY	NUMBER OF CERTIFICATES
China	32
Hong Kong	16
India	60
Indonesia	26
Japan	1000
Korea	247
Malaysia	46
Philippines	10
Singapore	50
Thailand	57
World total	**4400**

Environmental auditing (EA) examines or audits the implementation results of the EMS. The auditing results are the basis for the evaluation of the EMS implementation. Clearly, objective auditing is a key to the success of the EMS implementation.

EL

Environmental labels and declarations consist of three types of labeling programs. They are third-party operated ecolabeling program (type I), self-declared environmental claims (type II), and environmental declarations (type III) using a preset category of parameters. The overall goal of environmental labels and declarations is to encourage the demand for and supply of those products and services that cause less stress on the environment, thereby stimulating the potential for market-driven continuous environmental improvement (ISO/FDIS 14020, 1998). Manufacturers, importers and distributors are interested in using the environmental labels and declarations for the marketing of their products. However, the use of environmental labels and declarations shall be made through communication of verifiable, accurate, and not-misleading information on environmental aspects of products or services.

EPE

Environmental performance is the result of an organization's management of its environmental aspects. Environmental Performance Evaluation is an internal management process and tool designed to provide management with reliable and verifiable information on an ongoing basis to determine whether an organization's environmental performance is meeting the criteria set by the management of the organization. To be specific, EPE is a process to facilitate management decisions regarding an organization's environmental performance by selecting indicators, collecting and analyzing data, assessing information against environmental performance criteria, reporting and communicating, and periodic review and improvement of this process. EPE is an ongoing process of collection and assessment of data and information to provide a current evaluation of performance, as well as performance trends over time (ISO/DIS 14031, 1998).

LCA

LCA is a process that evaluates the environmental burdens associated with a product or service by identifying energy and materials used and wastes released to the environment; and which assesses the impacts of those energy and material uses and emissions on the environment. The scope of LCA should include the entire life cycle of a product or service encompassing materials and energy acquisition, manufacturing, use and waste disposal (Finnveden, 1996).

An LCA consists of four components (ISO 14040, 1997). They include:

1. Goal and scope definition

The goal and scope of an LCA study is defined and consistent with the intended application.

2. Inventory analysis

It involves data collection and calculation procedures to quantify relevant inputs and outputs of a product system. These inputs and outputs may include the use of resources and emissions to air, water and land associated with the system.

3. Impact assessment

It aims at evaluating the significance of potential environmental impacts using the results of the life cycle inventory analysis. This process involves associating inventory data with specific environmental impacts and attempting to understand those impacts. The impact assessment may include (1) Classification: assigning inventory data to impact categories, (2) Characterization: quantitatively assessing the relative contribution of inventory data to its assigned impact categories and aggregating the contributions within the impact categories (Finnveden, 1996),(3) Normalization: relating the characterization results to the total magnitude of a given impact category in a given area and time (SETAC, 1993), and (4) Weighting: weighting against each other of the relative importance of the different impact categories and aggregating them (Finnveden,1996).

4. Interpretation

Key environmental issues are identified and sensitivities of the results are tested. Dominance analysis is a method of choice in identifying key issues.

New and Emerging Areas

The activities of TC 207 are progressing as needs arise. New and emerging areas for standardization include Design for Environment (DFE) (TC207/WG1), Type III environmental declarations (SC3) and Environmental Auditing for Site Assessment (SC2).

An *ad hoc* group was formed in the San Francisco TC 207 meeting in 1998 to investigate the need and feasibility for an ISO document on Design for Environment. The Design for Environment is a design approach that considers environmental aspects for the design of a new product. A product developed based on Design for Environment would exert less stress on the environment compared to the equivalent products in the market. France and Germany will lead the group and will present the study results in the TC 207 meeting in Seoul 1999. The group belongs to WG 1 of TC 207.

Type III environmental declaration has been on the standardization agenda since 1994. However, SC 3 decided to produce Technical Report type 2 instead of a standard in the 1998 San Francisco meeting. The report is to be completed by June 1999 and the fate of Type III environmental declaration standardization will be discussed after the publication of the report. There are reasons behind the decision i.e. different interests from different countries and industrial sectors. Notwithstanding the decision to lower the status of the Type III environmental declaration document, it was a consensus that Type III environmental declaration is an environmental declaration of the future.

SC 2 created a task group in the 1997 Kyoto meeting for environmental site assessment. This group will draft a document (CD 14015) pertaining to the checklists and evaluation methodology for the auditing of a site specific environmental impact assessment. The assessment includes not only site but also activities, processes and services. Environmental aspects including energy and emissions to air, water and land are also part of the assessment. The standard is expected to have significant impact on the transactions of a corporation with sites contaminated with hazardous and toxic chemicals.

Relationship Between the ISO 14000 Series Standards

Although each standard in the ISO 14000 series has its own application, all the standards in the ISO 14000 series can be classified into two main categories based on the application target. One is for the system and the other is for the product. The ISO 14001, 14010 and 14030 series belong to the system standard. The ISO 14020 and 14040 series belong to the product standard.

Figure 2 further clarifies the relationship between standards in the ISO 14000 series. EMS on the left of Figure 2 indicates that EMS is a basic foundation for any attempt to manage a corporation in an environmentally friendly mode. Once you build up an EMS in your corporation, then you can strive for marketing your product through the use of the environmental labels and declarations, which is situated on the far right in Figure 2.

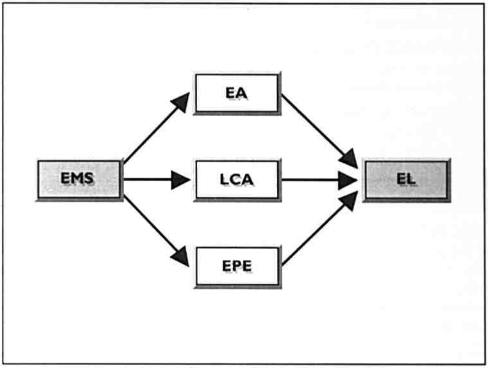

Figure 2 : Relationship Between the ISO 14000 Series of Standards

After all, corporations exist when they make profits by selling the products. Product sales can be increased through marketing. When a market is aware of the need for environmental preservation, the environmental labels and declarations would certainly contribute to increased sales of the product. Thus, environmental labels and declarations are the ultimate application of the ISO 14000 series for the corporation.

EA, LCA and EPE standards are situated in between. This indicates that they serve as bridges between EMS and EL. EA is needed to ensure proper implementation of EMS, as is EPE. LCA is used to identify key environmental aspects of a product or service such that the LCA results can be used both for the identification of key issues and for the implementation of EMS and EL.

In summary, EMS is a framework or foundation for a corporation to do business in an environmentally friendly fashion and an independent third party can certify the corporation's EMS activity. This is the certification based on ISO 14001. EL is a form of advertisement that a product or service of a corporation is environmentally friendly so that consumers are encouraged to purchase it. Meanwhile EA, EPE and LCA are supporting tools for EMS and EL.

THE IMPACT ON THE ENVIRONMENT AND BUSINESS

Future society predicted by the Organization for Economic Co-operation and Development (OECD) countries would be based on a non-material economy. In other words, the society is maintained by the service oriented economy. This means that wealth is created without resource consumption.

In order not to consume virgin resources, one has to use the existing resources which have already been extracted from the earth, over and over again. Existing resources must be recycled in a closed or open recycling loop indefinitely.

Together with the issue of resource consumption, environmental impact caused by products or services is also a major issue faced by human society. Global environmental impacts such as global warming and stratospheric ozone depletion pose a great danger to the survival of the human race. Regional as well as local environmental impacts such as acidification, eutrophication, photochemical oxidant creation, ecotoxicity and human toxicity also damage the ecosystem's stability and human health.

Consensus has been built up in the world that detrimental environmental impacts, especially global impacts, must be abated. International conventions on greenhouse gases and ozone depleting substances (CFC ban) are typical examples. Regional and/or local regulations have also been promulgated and enforced in recent years, mainly in western Europe. Regulations based on the EPR policy such as the packaging and packaging waste order in Germany are typical examples.

International conventions and regional and local regulations in the environmental area are created to save the earth and human species from the uncertain future of the earth resulting from resource depletion and environmental disaster. Thus, proper implementation of these conventions and regulations will certainly help our society to maintain its living standard and lifestyle for many generations to come.

However, there is another side of the coin. These conventions and regulations are potential technical barriers to trade. Industrialized countries with sound environmental policies in effect could require imported products to meet their own environmental criteria. Private corporations may impose strict environmental requirements for the components or materials they procure for the sake of implementing a green purchasing network (GPN).

In light of the possibilities of environmental conventions and regulations becoming technical barriers to trade, the international community decided to harmonize these practices and the net result is the publication of the ISO 14000 series. This is the very reason why countries exporting products to the developed countries should pay close attention to the contents, applications and implications of the ISO 14000 series.

The impact of the ISO 14000 series on the environment and business may be estimated by analyzing the activities of governments, businesses, and international organizations. Following are brief analyses of the possible impacts of each standard on the environment and business.

ISO 14001: EMS

The goal of ISO 14001 is to prevent pollution at the source and to achieve continual improvement of the environmental performance of an organization. If an EMS based on ISO 14001 is implemented to its full extent possible by most organizations in the world, then the environmental quality over what we have today would be improved significantly. Future generations would enjoy current living standards as well as better environmental quality.

The other side of ISO 14001, however, is its potential to act as a technical barrier to trade. To put it in plain terms, without an ISO 14001 certificate one may not run one's business, especially one engaged in export and international bidding. ISO 14001 is the only standard in the entire ISO 14000 series that issues certificates. An independent third party accredited by an accreditation body audits the EMS framework as well as EMS performance of a corporation, and issues an ISO 14001 certificate if it meets specifications in ISO 14001.

Buyers from developed countries often request from their supplier(s) evidence of the environmentally friendly operation of the corporation. The only objective evidence for this request is to provide an ISO 14001 certificate. Any other evidence such as compliance to local environmental regulations does not mean much to the overseas buyers. The request has been a norm for the electronic component suppliers in Korea, for example.

Request for qualification in international bidding projects often includes evidence of the environmental management system in place by the bidder. An ISO 14001 certificate is the only acceptable evidence. This is the reason why most construction and engineering companies in Korea obtained ISO 14001 certification as soon as the standard became official in September 1996.

An ISO 14001 certificate is merely proof that an EMS is in place in a corporation. It does not guarantee that the environmental performance of a corporation is superb. However, the very fact that a corporation has an EMS based on ISO 14001 would provide ample opportunities to make progress not only in improving the environmental performance but also in meeting the basic requirements of the global business community. In addition, conscious implementation of ISO 14001 will generate profits for the corporation. In short, adopting and faithfully implementing EMS based on ISO 14001 is a win-win strategy for any organization.

The ISO 14020 Series: EL

Continuous improvement of environmental performance and pollution prevention are the two most important goals of environmental management for producers. While pursuing these goals, it is natural that producers want to materialize the effort given to environmental management into increased market share of their products. This can only be achieved through the use of environmental labels and declarations.

Environmental labeling programs standardized by ISO can exert significant impact on the market where the environmental awareness of the consumer is high. The World Trade

Organization (WTO) recognizes that environmental labeling can be potential trade barriers. They stated that one of four Technical Barriers to Trade (TBT) principles is applicable to the environmental labeling standardization process. The principle says that the standardization of environmental standards should promote international trade and maintain fair trade practice.

Since environmental labels and declarations are directly linked to product marketing, the implication of the standards on the market, especially to international trade, is significant. The proliferation of non-verifiable, deceptive and inaccurate self-declared environmental claims, which would have distorted the market, will be eliminated once ISO 14021 is fully practised. Prior to ISO 14021, countries with their own guidelines on the self-declared environmental claims may have had a difficult time regulating the environmental claims for the imported products. The regulations may have been viewed as technical barriers to trade. Once the standard is finalized, however, this will be no longer the case. Any country wishing to implement regulations for the self-declared environmental claims based on ISO 14021 can do so without any challenge from abroad.

Countries with high environmental performance can benefit most from ISO 14021 and ISO 14024. Before one can make environmental claims or apply for the eco-label, one must show the environmental load of the products or services under consideration. This will require tools like LCA and costs associated with carrying out an LCA study. What is more challenging is to prove that their products or services are indeed environmentally friendly. Products from developing countries may have difficulty in meeting this requirement. This means that products from developing countries cannot use environmental labels and declarations as a marketing tool in developed countries. By the same token, products from developed countries would enjoy using the standards as a marketing tool.

The choice of whether to use the Eco-labeling program or the self-declared environmental claims may depend on the nature of the market. For countries where environmental labeling is more common and where stronger efforts have been made for LCA and environmentally friendly products, most likely EU countries, the Eco-labeling program should be the choice. For countries where corporations want to appear to be offering 'green' products but have taken a less serious approach to defining 'green' in their products, the Eco-labeling program should not be the choice. Furthermore, when consumers want to choose the environmentally friendly products at their own discretion, the Eco-labeling program is not a good marketing tool. Instead the self-declared environmental claims would be the choice and this type of situation most likely occurs in North America.

It is the general consensus that environmental problems of the present and future society may be solved through the implementation of GPN. If this is the case, the Type III environmental declarations will be used extensively among industries in the world. This indicates that corporations need to acquire LCA methodology as well as their own LCA data, and countries need to set up national and regional LCA databases and Type III environmental declaration programs.

The ISO 14040 Series: LCA

An LCA is a supporting tool for EMS and EL. EA and EPE are supporting tools for EMS. Of these supporting tools, LCA is the tool that exerts impact directly on the environment and business. This is because an LCA is an analytical tool that would provide clues to the solution of the environmental as well as resource problems we have today. Meanwhile, the other two tools are merely providing a means for the auditing of the EMS implementation and parameters for the evaluation of the environmental performance of a corporation.

A fundamental outcome of an LCA study is the identified key issues (activities, processes and materials) of a product system. These key issues are the starting point for any activities related to the environmental issues of a corporation to resolve.

A proper implementation of an EMS requires a correct assessment of the environmental aspects of a corporation. Life cycle consideration or screening level LCA are useful in identifying environmental key areas for a corporation to resolve. In addition, LCA provides an insight into the potential for environmental improvement of a product, which will lead to the development of environmentally friendly products. Thus, LCA is a vital tool for DFE.

The concept of LCA is simple. However, the practice of LCA requires expertise and an extensive database. Thus nationwide efforts should be given to establish LCA related tools and databases before one can utilize LCA to its full extent. This is a major obstacle for most developing countries.

DFE

DFE or ecodesign is considered an essential element for the realization of a sustainable society. The concept of DFE needs to be introduced here because DFE will be the ultimate target of the ISO 14000 series. An attempt by a corporation to deal with the EPR policy applicable to their product is given here as an example.

According to the EPR policy, a corporation manufacturing a product is responsible for the costs associated with the product's waste treatment and disposal. To reduce these costs, the corporation will try to design a product easy to disassemble and with components which are easy to reuse. The cost will further be reduced if the material for the components is recyclable. To this end, the corporation will incorporate a new product design concept that reduces the number of components and uses environmentally friendly materials, and will develop common components applicable to similar products. When recycling is not possible, the corporation will design a product that minimizes the quantity and toxicity of materials for incineration and/or landfilling. In short, a corporation will design a product that considers the environmental attributes of the product throughout its entire life cycle. This design approach is called DFE or ecodesign.

Efforts given to a DFE product can only be rewarded when the market accepts the product. Thus, environmental labels and declarations are used as marketing tools by the corporation. In both DFE and EL, an LCA is used to assess the environmental aspects of a product.

The impact of products designed for environment on the market will be enormous in the future. Environmental awareness of consumers will be heightened year after year, because the environmental and resource consumption problems will be aggravated continually. Any products which are not environmentally friendly will be eliminated from the market. One should realize that the traditional aspects of a product, e.g. quality, function, cost and safety, are basic requirements. Thus, the only differentiating factor in the near future is the environmental aspect. Allenby and Pugh (1992) of AT&T declared that there will be no corporation in the 21st century that does not consider the environmental aspects of its products.

Efforts given to LCA, EL and DFE research and applications began in the early 1980s in Europe. The same began in early 1990s in Japan: however, the rate of progress in Japan was so fast that current level is not far behind that of Europe. In 1998, the Japanese government (Ministry of International Trade and Industry : MITI) initiated a five-year project with a budget of 850 million Japanese Yen to develop LCA databases and other LCA related tools. A total of fifteen industrial sectors participated in this project voluntarily, and academia and research institutes carried out the actual work. The Korean government (Ministry of Industry and Resource) also sponsored a five-year project starting in 1998 with a total budget of two billion Korean Won to develop LCA databases and Ecoindicator values for common materials and processes.

Recently, Japan Sony developed and now successfully markets a radio equipped with a generator. The power to operate the radio is provided by manually rotating the generator which recharges electricity. One minute rotation powers the radio for thirty minutes. Japan Citizen also markets a watch that is operated by a solar cell under the brand name of Eco-Drive. The watch has an EcoMark from the Japanese Ecolabeling body. What is more surprising is that a new watch is under development using the temperature difference between the human body and the surrounding atmosphere. This new watch is being developed not only by Japan Citizen but also by the Phillips in the Netherlands at the same time (Yamamoto, 1998).

CONCLUSION

Human society has a legitimate goal to achieve: i.e. save the earth by not stressing the environment and by reducing resource consumption. No nation can argue against this noble cause. If we do not listen to the messages given by the environment such as global warming, stratospheric ozone depletion and resource consumption, our future will be bleak.

Concerted global efforts have been made to abate these environmental problems in recent years. Global conventions on global warming and stratospheric ozone depletion have been enacted and are enforced. However, there are many regional as well as local environmental problems and individual countries and regions promulgated various policies, regulations and practices to abate these problems. Typical examples include EPR, GPN, EMS, EL, LCA and DFE. These can serve as potential technical barriers to trade. This is the reason why there are the ISO 14000 series in the world today.

The ISO 14000 series are useful tools for the attainment of a sustainable society. They can help to mitigate environmental impacts associated with the activities of any organization, especially impacts associated with products and services. The other side of the coin, however, is that the ISO 14000 series may act as potential technical barriers to trade. Any standards are technical barriers to trade to those who cannot afford to meet the specifications of the standards. In this sense, the ISO 14000 series are no exception.

There is no option left but to comply with the standards if one wants to compete in the global market. One cannot just complain about the standards saying that it is too burdensome for developing countries to accept these standards. This is why one has to participate in the ISO standardization process actively.

Since most of the ISO 14000 series are already published or are in the final draft stage, the next best thing to do is to analyze the contents of the series and prepare what is needed to meet the standards. This includes the implementation of the EMS scheme based on ISO 14001, the implementation of Type I environmental labeling scheme based on ISO 14024, the adoption of environmental self-declarations based on ISO 14021 in the fair trade act, the development and implementation of Type III environmental declarations and the development of LCA methodologies and databases.

Government as well as industry sectors and individual corporations must realize that the ISO 14000 series could be a fatal trap in the near future for the developing countries engaged in international trade. The only strategy at this point is to prepare action plans on how to implement the ISO 14000 series.

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3 THE ORGANIZATION OF ENVIRONMENTAL MANAGEMENT FAMILY OF STANDARDS

ABU BAKAR JAAFAR

The development of international standards for environmental management is a response not only to the increasing responsibility assumed by industries for the environment worldwide but also toward sustainable industrial development to the growing demand of the market-place for "green" products and services, as a result of high awareness among consumers of various environmental issues at both local and global levels. The two driving factors, sustainable development and the growth of environmental-consumerism, have prompted the International Organization for Standardization (ISO) to establish a Technical Committee, namely, ISO/TC 207 on Environmental Management at the first committee meeting in Toronto, Canada, June 1993.

This overview provides a historical perspective that has led to the standard development, the scope, principles and structure of ISO/TC 207, and a discussion of the benefits accrued to various stakeholders, including the concerns of developing countries, particularly over the issues of trade and the environment.

BACKGROUND IN PERSPECTIVE

The inefficiency of the traditional market place in allocation of resources, be they materials or energy, has been the "root of environmental problems". This has caused excessive generation of "unwanted" or "misplaced" resources which have caused pollution. The response to pollution problems has continued to be regulatory intervention by enacting a series of environmental laws, regulations, and effluent or emission standards as well as the criteria for ambient air and the receiving waters for various beneficial uses. Such a Governmental "command and control" approach, while necessary and required, has yet to be adequate or sufficient to bring about a significant progress or improvement to the quality of the environment. Thus, a "complementary" approach or "self-regulation" over and above the minimum regulatory requirement has to be explored and realized as a standard industrial practice.

In 1984, the International Chamber of Commerce (ICC) organized the first World Industry Conference on Environmental Management (WICEM I) in France. One of the resolutions adopted by the industrial leaders at the Conference was that "the time of confrontation over environmental matters is behind us", that industry "recognizes the common responsibility of all parties for protecting the environment" and that "...environmental management should be an integral part of economic development." The ICC through their publications on *Environmental Guidelines for World Industry* in 1986 and on *Guide to Effective Environmental Auditing* in 1989 have been promoting the "self-regulation" approach:

> " In recent years public concern about the environment has led to much new legislation in many countries, and to numerous international conventions and other accords. The business community recognizes the need for a regulatory framework in the environmental area...inherent in all ICC activities is the strong belief in maximizing the *use of self-regulation* by the business community in the spirit of responsible care. The belief is based on two fundamental considerations:
>
> First, if properly applied, *self-regulation* is frequently, more effective than reliance on legislation and official regulations. Secondly, "excessive proliferation of regulations is counter-productive...The ICC believes therefore, that effective protection of the environment is best achieved by an appropriate combination of legislation/regulation and of policies and programs *voluntarily* by industry..."

In 1991, the ICC organized the WICEM II to assess the progress of business in improving environmental management practices and to establish an action plan for the years ahead, especially towards the UN Conference on Environment and Development (UNCED) in 1992 at Rio de Janeiro, and launched its "Business Charter for Sustainable Development". This Charter outlines 16 major principles on environmental management, supported by over 1,000 companies and business organizations throughout the world.

About the same time, the Business Council for Sustainable Development (BCSD), an independent group of business leaders from corporations around the world, released their position in a report "Changing Course", in which the idea of International Standards for Environmental Performance based on the concept of sustainable development was suggested. Such standards would help organizations in various sectors of the economy to measure their environmental impacts themselves on the basis of agreed and comparable performance criteria. The Council thus recommended that the ISO establish a formal Technical Committee (TC) on Environmental Management.

In the same year, 1991, ISO formed a Strategic Advisory Group on the Environment (SAGE) to make recommendations regarding international standards for the environment. After developing draft documents outlining the substantive content of potential standards, SAGE recommended that an ISO technical committee formally consider and produce final "consensus" on the standards for environmental management systems. In June 1993, the ISO/TC 207 Environmental Management was thus established.

SCOPE OF ISO/TC 207

The scope of the ISO/TC 207 covers "standardization in the field of environmental tools and systems". The focus of the Committee is on *management*. The Committee does not, however, set limit levels of performance criteria for operations, products, or services; instead, its activities are based on the philosophy that improving management practices is the best way to improve the environmental performance of organizations, their products or services.

PRINCIPLES

The ISO 14000 series of standards are being developed based on the following principles:

1. The standards must result in better environmental management.
2. They must be applicable in all nations.
3. They should promote the broad interests of the public and the users of the standards.
4. They should be cost-affective, non-prescriptive, and flexible to allow them to meet the differing needs of organizations of any size worldwide.
5. They should be amenable to both internal and external verification.
6. They should be scientifically based.
7. Above all, they should be practical, useful and usable.

STRUCTURE OF ISO/TC 207

TC 207 is the *umbrella* committee under which several types of environmental management standards are being developed by the following subcommittees:

Subcommittee (SC)	Standard
SC1	Environmental Management Systems (EMS)
SC2	Environmental Auditing (EA)
SC3	Environmental Labels & Declarations (EL)
SC4	Environmental Performance Evaluation (EPE)
SC5	Life Cycle Assessment (LCA)
SC6	Terms and Definitions

Also established under the Technical Committee are the following working groups:

Working Group	Document
WG1	ISO Guide 64 Guide for the inclusion of environmental aspects in product standards (for standard writers)
WG2	Guide for forestry industries in applying environmental management systems to their activities

ENVIRONMENTAL STANDARDS SERIES

Since its establishment in June 1993, TC207 has introduced and published six standards as of its 5th Plenary in Kyoto, April 18 - 25, 1997. These are:

ISO14001	Specification
ISO14004	Guide for Environmental Management Systems (EMS)
ISO14010	General Principles of Environmental Auditing (EA)
ISO14011	Procedures for Auditing of EMS
ISO14012	Qualification Criteria for Environmental Auditors
ISO Guide 64	Environmental Aspects in Product Standards

There are at least 13 other standards to be developed and published within the next 3 years:

ISO14040	Life Cycle Assessment (LCA)
ISO14041	LCA: Inventory Analysis
ISO14050	Terms and Definitions
ISO14021	Environmental Labeling (EL), Self-Declaration Environmental Claims
ISO14020	EL Goals & Principles of all Environmental Labeling
ISO14022	Self-Declaration Environmental Claims - Environmental Labeling Symbols
ISO14023	EL: Self-Declaration Environmental Claims: Testing and Verification Methodology
ISO14024	EL: Environmental Labeling Type I: Guiding Principles, Practices and Criteria
ISO14031	Environmental Performance Evaluation (EPE)
ISO14042	Life Cycle Impact Assessment
ISO14043	LCA Interpretations
ISO14025	Environmental Labeling Type III: Guidelines Principles & Procedures
ISO14015	Environmental Assessment Sites & Entities
Type 3	Technical Report on Forestry

STANDARDIZATION BENEFITS

The adoption of environmental management systems is not incompatible with competitiveness. All organizations can expect EMS to enhance their competitiveness in at least two major ways. Firstly, EMS provides a more comprehensive management framework to help them re-examine their process to enable them to become more resource efficient and less pollutive, thus leading to cost savings in the long run. Secondly, adoption of EMS gives a clear signal to consumers that the company is an environmentally responsible organization. It will improve the company's corporate image. It will also improve the company's competitive advantage in the international market, especially in markets where consumers place much importance on environmental attributes of the product.

There are of course numerous other types of benefits, including the following:

1. Complying with legislation in an efficient and systematic manner
2. Promoting self-regulation
3. Minimizing environmental risk and liabilities
4. Above all, providing continual environmental improvement

STANDARDIZATION ISSUES

Essentially there are two important issues relating to the development of international environmental standards. First is that relating to the needs of organizations in developing countries. Indeed this issue has been of ongoing concern to TC 207 ISO member bodies in many developing countries which were early to recognize the potential significance of the ISO 14000 series in their development process. The participation of many developing countries is somehow limited, however, by the lack of industry-wide support.

Secondly, there are concerns of small and medium sized enterprises (SMEs) in implementation of the standards. The concerns of the developing countries have been met to a certain extent by the assistance of several ISO member countries through donations of funds through ISO/DEVCO which coordinates the participation of selected developing countries' representatives largely in Technical Committees. To meet the concerns of SMEs, TC 207/SC1 has undertaken an initiative worldwide by organizing a series of case studies on the implementation of the ISO14001 and ISO14004 standards. It has also assigned a project team to gather information on the needs of the SMEs. The team is lead by Spain with representatives from Brazil, Malaysia and Mexico.

CONCLUSION

In short, the International Organization for Standardization (ISO) is facing a challenge in that it has to strike a difficult balance between the need to improve the environment which requires specific standards and the desire to facilitate trade which requires more general standards. The standards themselves, of course, do not necessarily guarantee environmental improvement. Crucial to such an improvement are the questions of 'morals' and 'ethics' that must govern all involved in the process: practising organizations and their consultants, registrars, auditors and the level of enforcement or rather reinforcement by national legislation that needs to complement the voluntary efforts of the industries.

From a trade perspective, ISO14000 standards have the potential to bring more benefits, not burdens, should exporters from developing countries be well informed or rather take the trouble to make themselves aware of the standards' developments and their implications. It is quite evident that pressure is being exerted on companies in developing countries, whether they be of foreign or local origin, by their trading partners in industrialized countries to implement an EMS and to become ISO14001 certified. The certification will become imperative for such companies to ensure a competitive advantage.

To promote worldwide applications of the standards without undue burden to local companies in developing countries it is expected that large companies be they, foreign or local, must provide an "umbrella" or introduce a "mentor-mentee" scheme which will help small and medium enterprises achieve the set standards through information exchange, capital investment, technology transfer and cooperation, deployment of experts and expertise, and development of other necessary local infrastructures including electronic websites.

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4 RELATING THE ENVIRONMENT AND EMS-STARTING WITH THE BASICS

ABDUL HALIM SULAIMAN
MOHD. IZHAN MOHD ILHAN

So you have decided to get into Environmental Management Systems. And you cannot remember all the things you were taught on the environment all those years ago. Well, do not worry. Help is at hand. We have written this chapter with the express purpose of giving you an introduction to some basic environmental concepts. It is important that anyone involved with EMS has at least a basic understanding of the environment and the way it works. Giving you a detailed explanation on the environment is impossible however, due to space limitations and would be redundant in any case, as there are many good books on the subject already. We encourage you to read some of them, and have provided a list of references at the end of this chapter.

GETTING DOWN TO THE BASICS

In the environmental line you will inevitably come across some of the following terms: Biosphere, ecosystems, ecology, biotic and abiotic factors and many more. Some of the more common terms are explained below.

Biosphere — Includes all the living (and once living) organisms found on Earth. The biosphere extends to the deepest depths of the oceans where there is life to the highest mountains where living things can survive.

Lithosphere — Is the crust and upper mantle layers of Earth.

Hydrosphere — Includes all permanent water bodies on the planet such as lakes, rivers, oceans and swamps.

The interactions of all the organisms in the biosphere with each other and the non-living environment (energy and chemical) and with the lithosphere and hydrosphere produce what ecologists call the **ecosphere**. It is the study of the ecosphere that is called ecology. The ecosphere itself can be broken up into many parts which are called **ecosystems.**

Ecosystems — The living components of an area, including all animals, plants and microbes interacting with the non-living elements of an area. Ecosystems can be large, for instance a tropical rainforest ecosystem, or very small, for example the small pool of water inside a hollow bamboo stem.

Biotic Elements of the ecosystem include all living organisms in a particular ecosystem, from the largest trees and mammals to the smallest microorganisms. Together, these elements form the **biotic community** of an ecosystem.

Abiotic Elements of the ecosystem include such factors as temperature, salinity, soil and availability of water. Abiotic factors exert a controlling effect over the biotic community that can survive within the ecosystem.

Species Refer to the many types of different organisms we see around us. An easy way to define organisms of the same species is to say that all organisms that look very similar to one another belong to the same species. Technically, organisms of the same species must be able to breed and produce *fertile* offspring - that is, offspring that can breed and produce offspring of their own.

Population Refers to a group of organisms of the same species living in a particular area. Populations of different species make up the living community of a particular area.

Producers Organisms that can manufacture the organic molecules they require for energy. Most producers are green plants that use photosynthesis to produce high-energy organic molecules from low-energy inorganic molecules. These range from the giant redwood trees to tiny phytoplankton and algae.

Consumers Those organisms that cannot manufacture organic molecules from inorganic ones and must therefore consume other organisms to obtain the nutrients they require. Consumers can be further divided into classes. Primary consumers are those organisms that eat producer organisms. They range from microscopic zooplankton to the mighty blue whale. Secondary and higher organisms eat other organisms that are ranked lower than themselves in the food chain.

Detritus feeders and Decomposers The third category of organisms. These feed on dead organic material by secreting substances to break down the complex organic molecules into simpler forms which can be ingested and used by the organism, or by eating the dead matter and converting it into organic compounds which can be used by the organism.

Food chain Basically a ranking of who eats whom or what. A typical food chain starts with a producer organism and goes through one or more consumers, each eating the one ranked lower than itself. For example, leaves (producer) are eaten by caterpillars (primary consumer), which in turn are eaten by robins (secondary consumers) which are then eaten by hawks (tertiary consumers).

Food web

A series of interconnected food chains. Organisms are seldom, if ever, part of only one food chain. The different pathways by which an organism consumes or is consumed form the food web.

Trophic levels

Hypothetical levels where all animals that feed on similar food are grouped together. Producers form the first trophic level. Successive levels of consumers form the higher trophic levels.

Niche

Refers to the specific role and place of the organism within its environment and includes its habitat, place in the food chain, etc.

Energy flow

The movement of the energy in organic molecules from one organism to the next as it is consumed. The energy for all living things originates from the sun. Green plants use this energy to produce organic molecules as mentioned earlier. When these plants are eaten by primary consumers, the energy is transferred from the plant tissues to the consumers.

Nutrient cycle

Refers to the recycling of nutrients in the ecosphere. In a natural setting, nutrient atoms like carbon, phosphorus and nitrogen are cycled through various organisms and back into the environment repeatedly. We shall explore these cycles in greater detail later.

PUTTING IT ALL TOGETHER

Now that you have a basic understanding of some of the concepts in ecology, it is time to see how they all work when put together.

Interactions between Organisms

As mentioned above, organisms can be divided broadly into three categories; producers, consumers and detritus feeders/decomposers. There is an endless cycle of interactions between these categories of organisms.

Producers are broadly responsible for feeding the consumers. Producers take mineral and other nutrients from the surroundings and use sunlight to help form simple and complex organic molecules which are high in energy. These high energy molecules are then used as food or fuel for growth and other chemical reactions within the producers. The energy absorbed from the sun is therefore locked within the tissues of the producers.

Primary consumers, or herbivores, consume the producers and are in turn eaten by higher consumers. In this way, the energy which was trapped in the tissues of the producer is transferred into the bodies of the consumer. Detritus feeders and decomposers break down the bodies of both producers and consumers on their deaths, gaining energy and nutrients for themselves and returning nutrients to the environment.

Apart from feeding relationships, organisms also interact in other ways. Plants, for example, also provide shelter for many other species, whether they are animal species or other plants. Animals can serve as modes of transport for other organisms. For example, barnacles that grow on the shells of crabs and other crustaceans get the double benefit of mobility and having access to the remains of the crustacean's meals.

Interactions between Organisms and Their Surroundings

All living organisms are the result of evolutionary interaction with their environment. The unique traits of any living species can be linked with a need to better adapt itself to the environment in which it lives, or to exploit a particular ecological niche to the fullest. To this end, organisms have developed a wide range of adaptations to deal with the environment.

Factors such as the prevailing weather, availability of water and nutrients, soil type and available shelter all play a part in the evolutionary process. The various demands the environment places on living organisms lead to the great diversity of living forms we see today. For example, the cold weather in the Arctic and Antarctic regions has forced animals to develop ways to deal with the low temperatures, including thick fur, small ears, thick layers of fat, etc. Plants which live in temperate regions have become so well adapted to the changing seasons that they actually require a period of freezing temperature to begin their life-cycle the following spring.

Living organisms also have an effect on their surroundings. For example, if a barren field is left undisturbed, grass and weeds will begin to grow, their roots helping to ventilate the soil. Legumes may also start to grow, enriching the soil with nitrogen compounds and making it possible for bigger plants to grow. After a long period of time, what was once a barren field could become a lush woodland.

Living organisms take nutrients from the environment. Plants take minerals from the soil and use them to grow and propagate. Animals eat the plants and return some of the nutrients to the soil in their feces and when they die and their bodies decompose. There is a continuous cycle between living things and the environment that has been going on since life first began.

Range of Tolerance

Abiotic factors play a determining role in deciding which organisms can survive and thrive in a certain area. All organisms have a certain range of physical conditions to which they are adapted. Should any physical or chemical factor in the environment fall below or rise above the range of tolerance of the organism, then it is likely that the organism will die. In fact, the closer these factors approach the limits of tolerance of the organism, the more stress it experiences. Therefore, certain species are only found where the physical and chemical environment are suitable for their survival and continued well-being. For example, freshwater fish will only be found in water that is relatively salt free. If you add salt to the water, only fish which can tolerate the increased salinity will stay in the area whereas other species will attempt to move away. If they cannot escape, they will become distressed and may die.

In this way, too much or too little of any element will limit the species that can live under those conditions. Even if all the other factors are at or near their optimum levels for that species, as long as one factor is beyond the limits of tolerance for that species, that species cannot survive in that ecosystem. This is called the Law of the Limiting Factor. This law can be used to explain why species die out when pollution of their natural environment occurs.

Abiotic factors are not the only ones capable of serving as limiting factors. Biological factors are just as capable of limiting the spread or growth of other species. Competition between species will ensure that only the species best adapted to extract the most from its surroundings will survive. Disease-bearing organisms will limit the spread of species not resistant to the diseases they transmit. Predators will control the numbers of prey so that the numbers of prey organisms do not increase beyond a certain limit.

Energy

Energy is basically the ability to do work. Although it appears that there are many different kinds of energy, all energy can basically be divided into two categories - kinetic energy, which is the energy of movement, and potential energy, which is the stored ability to do work. Potential energy is energy possessed by an object due to its position or condition, for example, a stretched rubber band has the potential to snap back into its original loose state. Kinetic energy is the energy of movement. Light, sound and heat are forms of kinetic energy, which are due to the vibration of atoms and molecules. All the work we see involves changes from one form of energy to the other, from potential to kinetic and *vice versa.* However, in changing from one form to another, some of the energy is lost, in the form of heat, and possibly other forms. This is because no reaction we know of is 100 percent efficient in transforming energy from one form to another.

The Energy Pyramid

Life on earth is possible because of the sun and green plants. The sun is the source of energy for every living organism on Earth. Green plants possess a pigment called ***chlorophyll,*** which gives these plants their color. Chlorophyll is able to utilise the energy from the sun to produce simple sugars (which it uses for food) from a combination of carbon dioxide and water, leaving oxygen as a by-product. These sugars are used as a fuel for the building of new cells and tissue. The sun's energy is therefore stored in the plant's tissues. When an animal eats the plant, this energy is transferred to the animal. However, a sizeable portion of this energy is lost in the process in the form of heat. The same process of energy loss occurs when the first animal is eaten by the next one, and so on up the food chain. This explains why there are decreasing numbers of organisms in the higher trophic levels.

Entropy

Entropy is the degree of disorder in the universe. This may seem a strange concept, but it is central to the mechanisms of life. Without energy input, all reactions head in one direction—toward increasing entropy. This should be obvious from observation of everyday life. Buildings become dirty and chipped unless they are maintained, human body functions become erratic unless enough nutrients are supplied *via* food and cities would become clogged with rubbish unless effort is made to collect and transport the garbage. The conversion of energy and the loss as heat are both aspects of increasing entropy.

Laws of Thermodynamics

One of the fundamental things to know about energy is that it cannot be created or destroyed, but it can be changed from one form to another. This law is called the **Law of Conservation of Energy** or the **First Law of Thermodynamics**. Apart from this, some energy is lost in the form of waste heat for every reaction that takes place, so you end up with less useful energy after every reaction. This is the **Second Law of Thermodynamics**. Another name for this law is the **Law of Diminishing Returns**.

Based on these two laws, it becomes clear that any system requires continuous input of energy to continue functioning. If energy input ceases, the system may continue functioning for a short time on its internal energy, then cease to function once this reserve is depleted. A good analogy would be your car engine. To keep it running, you have to keep filling up the petrol tank. If you don't fill up the tank, your engine will stop running sooner or later depending on its fuel economy. The second law of thermodynamics can also be stated thus: *Systems will go spontaneously in one direction only - toward increasing entropy.*

Matter Recycling in the Ecosystem

One of the principal features of functioning natural ecosystems is that they do not generate any waste. All matter is completely recycled in the biogeochemical cycles. Therefore, the nutrients which are essential to life are recycled and not lost from the system. It should be noted that there is an emphasis on the word natural in the first sentence of this paragraph. As yet, humans have been unable to discover a method of completely recycling everything they use. In the following paragraphs, we will discuss some of the more important biogeochemical cycles.

The Carbon Cycle

All life forms that we know of are carbon based. Carbon is one of the building blocks of life and carbon atoms are found in everything from carbohydrates, proteins and fats, to nucleic acids such as DNA and RNA. The carbon in living organisms actually comes from inorganic carbon in the atmosphere. Plants use carbon dioxide, a gas that makes up about 0.04 percent of our atmosphere to manufacture sugar and produce oxygen as a by-product. Through photosynthesis, the carbon dioxide is broken up and joined with hydrogen atoms to form simple sugars. When plants respire, they break down glucose to obtain energy and release carbon dioxide, just as do other aerobic organisms. Therefore, atmospheric carbon is recycled for reuse by producers. This is an important part of the carbon cycle.

Plants make use of the carbon dioxide which is produced by all aerobic living organisms through cell respiration and transform it into forms which can be used by all organisms. The organic molecules that plants produce for their use as well as the use of all other living organisms, tie up large amounts of carbon. This carbon will be released back into the atmosphere when the organisms die and decay, or are burned. Large quantities of carbon dioxide are released into the atmosphere every year through the clearing and burning of forests.

There is also a huge carbon reservoir in the form of fossil fuel beneath the Earth's surface. Fossil fuels are the remains of plants and animals that have been converted into their present form over millions of years of exposure to extremely high pressure and temperature. Needless to say, these compounds are high in carbon content. This carbon is trapped until released into the atmosphere as carbon dioxide when fossil fuels are burned. Another large reserve of carbon is trapped in the form of calcium carbonate, which forms the shells of bivalves and other crustaceans, as well as in limestone rocks. This reserve is trapped in the sediment of ocean beds and in rock formations and is released back into the atmosphere only very slowly through the melting of rock formations and volcanic activity.

The Nitrogen Cycle

Nitrogen is no less important than carbon is to the body. Living organisms require nitrogen in various forms to build proteins and genetically important nucleic acids such as DNA. As with the carbon cycle, plants are the major source of nitrogen compounds for animals. This time however, it is not the plants themselves which are responsible for manufacturing the nitrogen compounds. Indeed, the plants are themselves dependent on other organisms to fix nitrogen into forms they can use. Plants require nitrogen in the form of nitrate (NO_3^-) and ammonium (NH_4^+) ions. One would think that nitrogen supply would not be an issue with 78% of the Earth's atmosphere composed of nitrogen gas. However, nitrogen in this form is useless to plants and animals, as it is inert. Fortunately for us, there are organisms capable of converting atmospheric nitrogen into useful forms.

Organisms responsible for nitrogen fixation include cyanobacteria (which used to be called blue-green algae) and other forms of free living bacteria in soil and water, and rhizobium bacteria in the root nodules of leguminous plants. Legumes include plants such as alfalfa, clover, peas and beans. Lightning also plays a part in nitrogen fixation by converting nitrogen and oxygen gas in the atmosphere into nitric oxide and nitrogen dioxide gases. These react with the water vapour in the air to form nitric acid and particles of solid nitrate compounds.

When plants and animals die, specialized bacteria convert the organic nitrogen in their cells back to inorganic compounds such as ammonia gas (NH_3) and other water soluble salts containing ammonium compounds. Other specialised groups of bacteria convert these compounds into nitrate ions in the soil and nitrogen gas, which is released into the atmosphere to begin the cycle again.

The Phosphorus Cycle

Phosphorus tends to be the limiting factor for plant growth in many soils and aquatic systems. This is because the concentration of phosphorus in most soils is very small, and as phosphorus is highly insoluble in water, concentrations in most surface water is also low. Phosphorus is also found only in certain types of rock. This further limits its availability to plants and animals.

Phosphorus in its ionic form (mainly PO_4^{3-} and HPO_4^{2-}) is an essential nutrient for both plants and animals, which require them in order to build DNA molecules, as well as ATP and ADP molecules which store chemical energy for use by the organism during cellular respiration, certain lipids in the cell walls of plant cells and the cell membranes of animal cells, and bones and teeth in animals.

Bacteria are less important in the phosphorus cycle than in the nitrogen cycle. Phosphorus moves slowly from phosphate deposits in the land and in shallow ocean sediments without the aid of fixation bacteria. The absence of these bacteria or any other biological components means that the speed of useable phosphorus entering the cycle is much slower than in either of the two previous cycles. Phosphate is released by the slow weathering of phosphate rock deposits. The phosphate ions are dissolved in soil water and taken up in plant roots. Animals eat the plants and are in turn eaten by other animals. When these animals and plants die, decomposition returns much of this phosphate to the soil, to the rivers and finally to the sea, in the form of insoluble deposits of phosphate rock.

Some phosphate is returned to the land in the form of guano, which is the phosphate rich feces of fish-eating seabirds such as seagulls, cormorants, albatrosses and pelicans. This amount is miniscule however, when compared to the amount of phosphate which is washed from the land into the oceans through natural processes such as erosion and surface runoff, or human activities such as polluting rivers with phosphate rich waste materials.

The Hydrologic Cycle

Water is another substance which makes life on Earth possible. Water is also subject to a cycle which collects, purifies and distributes Earth's water supply. The prime movers of this cycle are sunlight, the heat of which causes evaporation, and gravity, which causes precipitation to fall back to Earth.

The heat of the sun causes evaporation from all water bodies, including the oceans, rivers, lakes and streams. The water vapour from these sources rises up into the sky, where it begins to cool at higher altitudes and recondense to form water droplets. These water droplets aggregate to form clouds which are then transported by global air currents to other locations, where the water in them may fall to earth as various forms of precipitation (rain, sleet, snow and dew).

Another important source of atmospheric water vapour is the respiration of living organisms. All organisms produce water as a by-product of cellular respiration. If you need proof, just hold a piece of glass in front of your nose and breathe on it - a thin film of water vapour will be evident on the glass. This water vapour is also an important part of the hydrologic cycle.

Several different occurrences are possible when precipitation falls back to earth. Rainwater may seep into the ground and collect in spaces in the rock layers deep underground. These aquifers are an important source of water in many drier climates, as underground springs and streams return the water to the surface. Fresh water percolates downwards through the soil to replenish aquifers. However, circulation of underground water is slow by comparison with other parts of the hydrologic cycle.

A large portion of precipitation simply runs along the surface and into streams, lakes and rivers, which eventually carry the water back to the sea to begin the cycle again. This surface runoff also causes erosion that moves various chemicals through portions of their own biogeochemical cycles. A small portion is locked in glaciers, where it may remain for long periods of time.

The Impact of Man on the Environment

It is safe to say that humans are the single most destructive species on the planet. Whereas most organisms adapt to their environment, we are forcing the environment to adapt to us. Although Earth as a whole is a tolerant mistress, capable of absorbing a great deal of abuse, we cannot continue with our destructive ways indefinitely. We are already seeing some effects of our abuse. Although a full discussion of the impacts of human beings on planet Earth is outside the scope of this work, we should be aware of the effects we are having on our environment. The following pages deal with some of the more immediate causes for concern.

SOLID WASTE

Defining Solid Waste

Everywhere you go, you will probably notice one or the other or both of these things - garbage and garbage bins. Simply put, solid waste is anything we do not want that is in a solid, as opposed to a liquid or gaseous form. Solid waste includes - and this is by no means a complete list - old newspapers, used aluminium cans, empty glass and plastic bottles, stale or spoilt food, old rubber tyres, and old television sets. In fact, anything manufactured by humans has the potential to become solid waste. In addition, many by-products of human activities can be classified as waste, for example the non-mineral containing rock excavated during mining.

Types of Solid Waste

Biodegradable waste is solid waste that can be decomposed by bacteria and other biological organisms into simple compounds which are not a danger to the environment. Examples include paper, wood and food products.

Non-biodegradable waste is solid waste that cannot be decomposed by bacteria and other biological organisms. It breaks down, breaks down extremely slowly or produces dangerous substances during decomposition. Most of these are substances such as aluminum, which breaks down very slowly, and plastics, which are produced industrially from petrochemicals and other fossil fuels.This waste will remain in its normal state almost indefinitely. It is this type of waste with which we are most concerned, since unless serious steps are taken to reduce the amount of this type of waste, we will end up burying the Earth in our refuse.

Plastics accumulate in the environment faster than any other forms of waste. Plastics and their related compounds are organic polymers synthesised from long chains of carbon atoms present in fossil fuels. In fact, manufacture of plastics is a significant part of the petrochemical industry. Although plastics are composed of what are essentially biological molecules, they are for the most part non-degradable due to the fact that each decomposer organism possesses only specific enzymes that enable it to break down certain chemical bonds between atoms. As each enzyme is specific in its action, they cannot break down molecules which do not possess these bonds. As plastics are manufactured as opposed to natural compounds, micro-organisms have not yet evolved that can break down these molecules.

Sources of Solid Waste

Mining and Agricultural Activities

Mining activities are the source of almost three quarters of the solid waste generated in the United States. The excess rock and minerals from excavation and processing are generally left on the site, exposed in slag heaps, dumped in the ocean or disposed of by refilling and landscaping disused mines. Problems arise when precipitation causes acid leaching from the mine waste. The acidic water often contains high concentrations of heavy metals that are toxic to most living organisms. This explains why disused mine land tends to be barren for extended periods of time. Mineral extraction processes can also contribute significant amounts of toxins to an already grave situation. Until quite recently, arsenic was used in the extraction and purification of gold. Once used, it was allowed to flow into the streams and rivers. Arsenic is one of the more toxic substances known to man and this misuse of it was responsible for decimating many aquatic ecosystems.

Agricultural activities also contribute a large percentage of solid waste generated in the United States, some 12 percent of all solid waste generated in fact. Agricultural waste comes in such forms as crop waste and animal manure. When traditional methods of agriculture were in place, this waste was recycled by composting the wastes and using them to fertilise fields. As more and more chemicals are being used in agriculture, these waste products have ceased to become useful and have instead become a cause for concern. A common practice in disposing of animal manure is to flush it into the nearest waterway, whereas plant wastes are burned openly in the fields. Both these methods lead to other forms of pollution which we will discuss later under the water and air pollution topics.

Industry

Many of the most hazardous and toxic forms of waste are by-products of industry. No matter what form they are in, whether liquid or solid, these wastes must be kept out of the water supply. They must therefore be contained in special containment areas until they are detoxified or, as in many cases, indefinitely.

Municipalities

This is the type of waste with which most of us are very familiar. All household wastes excluding what goes into the sewage system is included in this category. Excess food, soiled diapers, old newspapers and discarded electrical appliances all fall under this category, as do some items which should be treated as toxic waste such as spent insecticide cans, tins of hairspray and the like.

Solid Waste Disposal

Solid waste disposal has become increasingly important as the amounts of waste that we produce increases. Every day the United States alone produces more than 400,000 tons of municipal waste, more than twice as much as in 1960. Of this amount, more than one-third is made up of paper and paper products. The amount of non-biodegradable matter in our waste has been steadily increasing as more and more plastics and polymers are used in everyday products.

All this leads to problems of disposal. Most municipal waste is disposed of in landfills, with smaller quantities being dumped at sea, or burned. Each of these methods of disposal has its advantages and drawbacks, which are examined more closely below:

Landfills

Landfills are the most common method of disposing of large quantities of domestic waste. In this method, a large depression is dug in the ground, and waste is used to fill it up. Depending on the type of soil, the landfill may need to be lined to prevent water seeping out from the landfill and poisoning underground water. In areas where the soil is sandy and water can seep through freely, landfills need to be lined, either with plastic or with clay. It may also need a treatment plant to clean up any water that leaches through the waste before it reaches the local surface or ground water.

The main problem facing this method of waste disposal is the need for large land areas to dispose of the waste. This land will be unsuitable for other use for a long time. With the limited land areas available to us, a more viable alternative will become necessary before too long. As more and more landfills are filled to capacity, the need to remedy the situation becomes even more urgent.

Another concern is methane gas build-up in some landfills. Many types of municipal waste are biodegradable, meaning that they can be digested by living organisms. When exposed to air, these wastes are gradually broken down into simpler forms and carbon dioxide. However, when these wastes are buried in landfills, oxygen is denied to the waste. Under these conditions, waste is decomposed anaerobically, that is, without oxygen. The rate at which waste is decomposed under these conditions is much slower than if oxygen is present in sufficient amounts. Anaerobic decomposers also release methane as a by-product of anaerobic digestion. In older dumps, this methane may need to be vented to prevent an explosion. In fact, methane build-up in some older landfills may be so high as to make natural gas exploitation a viable option.

Apart from this, landfills also lead to wastage of large quantities of reusable items. Paper, glass and metals can all be recycled for use in new applications, rather than being buried or destroyed in landfills. Recycling these materials could lead to a large saving in the cost of producing new materials. Landfills are also expensive to maintain. In 1992, state and local governments spent almost US$120 per person in the United States to dispose of solid waste.

As mentioned above, a small percentage of municipal waste can also be classified as hazardous and should be treated as such, for example, old tires, batteries, cans of insect spray, empty detergent containers, old appliances etc. Although these items should be treated as hazardous waste, they are not, therefore increasing the possibility of toxic substances leaching into the soil.

Incineration

This method is commonly used to dispose of agricultural waste such as fallen trees, wheat stalks, etc. It is also used on domestic waste to reduce the volume of waste going into a landfill. Incineration has several serious disadvantages, not the least of which is the large amount of soot particles and gases such as carbon dioxide, carbon monoxide, nitrogen dioxide and sulphur dioxide that may be released.

Incineration also leaves a residue that is much more toxic than the whole waste. This is because the incineration has disposed of all the biodegradable matter and concentrated toxic substances such as heavy metals in the residue. This residue must therefore be treated as hazardous waste. Incineration also requires the use of fuel or catalysts, further increasing the cost of this method. Part of the cost of incineration can be recovered however, by using the heat it produces as a source of energy.

HAZARDOUS WASTE

This is waste that for one reason or another is dangerous to life. It may be toxic, radioactive or disease bearing. Industrialised societies generate millions of tons of hazardous waste every year. These wastes can be divided into several broad categories - Radioactive Waste, Toxic Chemical Waste and Biologically Active Waste.

Radioactive Waste

Although this is not a major problem in our country, radioactive waste is a global concern, mainly due to the policies of countries using nuclear power to export spent reactor fuel and coolant rods. Nuclear power plants are in use in many countries as they are seen as less polluting than fossil fuel powered plants. Nuclear reactors do produce a quantity of waste, however, which is much more hazardous than most by-products of fossil fuel burning powerplants. Nuclear reactors use either uranium or plutonium rods as fuel. When the radioactivity of a rod drops below a certain level, the rod is removed and a new one is inserted into the reactor.

Problems surface when it comes time to dispose of the fuel. Although the radioactivity of the spent fuel rods is low compared to a full strength rod, it is still well above the limits of tolerance for most organisms.

Radioactive materials damage living tissues by causing damage to proteins, lipids and genetic material. High energy radioactive particles can easily penetrate most containers and damage the genetic material of organisms nearby, causing cancer, mutation and death. Any child will probably have heard of the Teenage Mutant Ninja Turtles and how they came into being. However, it should be remembered that only 1% of all mutations are even remotely beneficial. The other 99% ranges from disadvantageous to fatal.

Toxic Chemical Waste

One way or another, most hazardous waste falls into this category. The main categories of toxic chemical waste are:

1. *Heavy metals* are elements such as mercury, cadmium, zinc and lead, that are poisonous to organisms when they occur in high enough concentrations. Heavy metals interfere with the action of enzymes in cells. Cadmium for example, which is used in the plating of certain metals and in batteries, can cause kidney and bone marrow disease as well as emphysema (lung damage). Heavy metals are naturally occurring elements, which are normally present in the Earth's crust in small quantities. The problem is that industrial and agricultural processes tend to concentrate some of these elements to levels at which they are toxic. As heavy metals are elements, they cannot be broken down, either chemically or by decomposer organisms. The only ways to dispose of them are to dilute them to levels at which they are no longer toxic, or to treat them with chemicals that convert them into less toxic compounds.

2. *Organic solvents* are used in industry and laboratories to dissolve compounds that do not dissolve in water. These solvents include hydrocarbons such as benzene, toluene and xylene, as well as organic compounds containing chlorine, such as carbon tetrachloride and trichloroethylene. As these substances are used to dissolve organic compounds, they can dissolve in the body's cell membranes and other fat, and can cause nerve damage. This group includes some of the most powerful carcinogens known to man. The only way to safely dispose of organic solvents is to convert them chemically into less toxic substances. Alternatively, they can be purified and reused.

3. *Organohalogens* are organic compounds containing the halogens - chlorine, bromine and fluorine. They are used as solvents, fire retardants and pesticides. Apart from being highly toxic, they are also highly persistent, remaining in the environment for many years after they have been used. This class of toxins includes the **polychlorinated biphenyls**, the use of which has been restricted since the 1970s due to the fact that they remain in the body's fat reserves for long periods of time.

4. *Dioxins and related chemicals* are unwanted by-products of the manufacture of some organohalogens used in making pesticides, wood preservatives and other products. They often remain as contaminants in the finished products. One of the best known dioxins is TCDD, which is found in the herbicide 2,4,5-T, and is often used on lawns. TCDD is better known as its code name - Agent Orange. Agent Orange is blamed for birth defects and genetic disorders among Vietnamese exposed to it during the Vietnam War. The town of Times Beach, Missouri, had to be abandoned in 1983 because tests indicated that highway spraying with oil contaminated with dioxins had left high levels of dioxins in the soil. The US EPA is currently conducting a review on dioxin toxicity. However, it may be a long time before the results are known.

Biologically Active Waste

Biologically active waste consists mainly of human and animal fluids and offal from places such as hospitals, laboratories and abattoirs. Such waste can serve as a vector for the spread of disease or a breeding place for pathogenic organisms. These wastes may also be contaminated with contagious elements such as viruses and bacteria. Proper procedures must be followed to dispose of this type of waste. Incineration is the most common method of disposing of this type of waste.

Disposal Methods

There are several different methods of disposing of toxic waste. The method employed depends on the type of waste involved.

1. *Detoxification* is used to treat some toxic wastes to convert them into substances that are not so hazardous. This can be done chemically, for example by adding lime to acids to convert them to harmless salts or by combining cyanides with oxygen to form carbon dioxide and nitrogen.

2. *Incineration* is used to dispose of certain types of toxic waste as well as biologically active waste. Incinerators require pollution control devices and careful monitoring to ensure that they do not release toxic by-products into the environment. One of the more effective methods of incineration is the rotating kiln, in which the waste is fed into a slowly rotating furnace and incinerated during its passage through the kiln.

3. *Secure landfills* are also used to dispose of those wastes that cannot be disposed of by detoxification or incineration. Most secure landfills are lined with double layers of impermeable clay with a drainage system to filter off any leachate from the dump. However, not even the best designed dump is totally secure, and in most cases, the toxic compounds stored in the dump will be able to seep out after a certain period of time, depending on how well the dump is designed. Once the dump begins to leak, it is only a matter of time before the toxic compounds it contains find their way into underground water, or into underground oil or natural gas wells.

4. *Bioremediation* is the use of decomposer organisms to detoxify toxic waste. Certain types of toxic waste can be detoxified by the action of decomposer organisms. Letting

decomposers do the work is often the least harmful method of cleaning up an oil spill. Natural bacteria has been found to be the best agent for the decomposition of polychlorinated biphenyls, which are broken down into carbon dioxide and water. This method does of course require a certain amount of time to clear up a toxic waste spill. It does however have the distinct advantage of producing almost no toxic by-products.

AIR POLLUTION AND ITS CONTROL

Air Pollution: A Global Concern

Air pollution is a grave source of concern for many countries. It is the only type of pollution that is free to cross any boundaries. After all, we can stop shipments of toxic waste from crossing our borders, or even divert the flow of rivers to prevent waterborne pollutants from reaching population centers, but who can chain the wind? Borne on air currents, air pollutants can be brought anywhere in the world. Nowhere is this more obvious than the ozone hole over the Antarctic, which was caused by chlorofluorocarbons from all over the globe.

Air pollution can be defined as the presence in the air of substances that adversely affect its chemical composition. Most, but not all, of the world's air pollution comes from man-made sources. There are some exceptions, notably volcanoes, which can affect global temperature when they erupt. Average global temperatures dropped by more than 1 degree Fahrenheit in 1991 when ash from Mount Pinatubo's eruption reached the stratosphere and blocked some of the sun's radiation.

Classes of Air Pollutants

1. Oxides as the name suggests, are compounds which contain oxygen, for example carbon monoxide (CO), carbon dioxide (CO_2), sulfur dioxide (SO_2), sulfur trioxide (SO_3), nitric oxide (NO), nitrogen dioxide (NO_2), and nitrous oxide (N_2O).

2. Volatile organic compounds (VOCs) are hydrocarbons such as methane, ethylene, benzene, benzopyrene and other organic compounds such as formaldehyde, carbon tetrachloride, chloroform, methylene chloride, ethylene dichloride, trichloroethylene, vinyl chloride and ethylene oxide.

3. Suspended particles and aerosols include dust soot, lead, cadmium, asbestos, chromium, arsenic, nitrate salts, sulfate salts, sulfuric acid, nitric acid, oil and pesticides.

4. Secondary pollutants include ozone (O_3), acetaldehyde, hydrogen peroxide, hydroxyl radicals, sulfuric acid and peroxyacetyl nitrates (PANs).

Oxides, VOCs, suspended particles and aerosols are primary pollutants, which are the direct result of chemical reactions that take place in places other than in the air, for example soot, which is formed in fires, or sulfur dioxide which is released when fossil fuels are burned. Secondary pollutants are the result of reactions between primary pollutants in the air. For example, nitrogen dioxide is a primary pollutant released from many chemical plants. In the air, nitrogen dioxide reacts with water vapor to form nitric acid, which is a secondary pollutant and one of the components of acid rain.

Sources of Air Pollution

Sources of air pollution are too numerous to list. However, they can be broken into broad categories.

Industrial Emissions

Industry has been a major source of pollution since the industrial revolution. Although most developed countries now realise the dangers of air pollution and have taken measures to combat and control air pollution, many developing industrialized nations are not wealthy enough to devote substantial resources to pollution control. Therefore, air pollution is still a problem in many countries.

Major air pollutants released by industry include sulfur dioxide, nitrogen dioxide, fly ash and other suspended particles. Some industries can take steps to control their emissions, for instance by installing electrostatic precipitators to remove fly ash, or scrubbers that pass gases through a spray of water to dissolve pollutants. However, some industries clearly cannot control their polluting emissions. A good example of this would be the quarrying industry, which produces tons of fine dust as a by-product of its activities. The smaller particles, i.e. those smaller than 10 micrometers in diameter, are freely respirable, meaning they can bypass all of our lung's defenses and enter our lungs. These particles can act as carriers for other pollutants, such as VOCs that can harm the tissues of our lungs. Also included in suspended particles may be particles of heavy metals such as titanium and zinc from the paint manufacturing industry.

Motor Vehicle Emissions

Vehicles with internal combustion engines (ICEs) are a major contributor to air pollution all over the globe. Incomplete combustion of the fossil fuel used in ICEs releases carbon monoxide, sulfur dioxide, nitric oxide and VOCs into the air. Carbon monoxide competes with oxygen for binding sites in our red blood cells - in fact, carbon monoxide is even more efficient in binding with the binding sites in the red blood cells. High levels of carbon monoxide in the air can lead to drowsiness and in extreme cases, death, as the body is deprived of oxygen.

The nitric oxide given off by ICEs reacts with oxygen in the air to form nitrogen dioxide, which is a yellow-brown gas with a strong, acid smell. Nitrogen dioxide is one of the chief components in photochemical smog, a yellowish haze that tends to occur in cities where there are very high numbers of motor vehicles. Ultraviolet light from the sun causes the nitrogen dioxide molecules to split, releasing a high energy, reactive oxygen radical. Some of these oxygen radicals react with oxygen molecules in the air to produce ozone, which is poisonous to most life forms. Nitrogen dioxide also reacts with oxygen to produce nitric acid, a component of acid rain. Sulfur dioxide reacts with water molecules to produce sulfuric acid, another important component of acid rain.

In recent years the increase in use of unleaded petrol has led to a decrease in the amount of lead particles entering the environment from fuel exhaust. Lead, as mentioned earlier is a toxic heavy metal, which can cause nerve damage in humans. However, it is more of a choice between the frying pan and the fire, because unleaded fuel contains benzene as an anti-knocking agent - and benzene is a powerful carcinogen.

Most motor vehicles are currently fitted with emission control devices in the form of catalytic converters that utilise platinum catalysts to convert the more harmful exhaust gases into less harmful forms.

Agricultural Emissions

Although it would seem that an activity such as agriculture would contribute little to global air pollution, it is actually one of the main contributors to the greenhouse effect, which we will read more of later. Cows and other ruminants (animals which have four chambers in their stomachs to help digest cellulose in plant material) release huge quantities of methane as the bacteria in their digestive tracts digest cellulose anaerobically. Methane is one of the so called "greenhouse gases" which contribute to global warming.

Apart from this, much agriculture in less developed countries is still done at a subsistence level, and this leads to new patches of jungle being cleared every year by slash-and-burn style farming. Uncontrolled open burning leads to the release of large quantities of carbon dioxide, soot and other pollutants into the atmosphere. Soot and dust particles can travel great distances when carried on the right wind currents. We need look no further than the 'haze' episodes of 1997 to see the drastic effect burning of forests can have when coupled with the wrong weather conditions.

The Effects of Air Pollution: A Global Perspective

As mentioned earlier, air pollution is a trans-national concern. Air pollution agents produced in one country can affect the air quality of its neighbours and even contribute to global environmental problems. Two of the more noticeable phenomena are the thinning of Earth's ozone layer, and global warming - the so-called "Greenhouse Effect".

The Ozone Layer - Earth's Shield

Life on earth is possible because of the sun and its light. Yet, without the ozone layer in Earth's stratosphere, the sun would be the cause of the cessation of life on Earth. Ozone is a moderately poisonous gas, which nonetheless serves a crucial role when in the ozone layer. The ozone layer is responsible for blocking up to 90% of incoming ultraviolet (UV) radiation from the sun.

Ultraviolet radiation is a high energy radiation which has the potential to damage genetic material, i.e. DNA and RNA, by altering the composition of essential proteins. UV radiation can cause the death or mutation of cells close to the surface of the body, resulting in skin cancer in humans and higher animals. Single celled organisms, for example phytoplankton, may be killed outright by increased doses of UV radiation.

Chlorofluorocarbons (CFCs) were discovered in the 1930s, and at the time, seemed like a chemist's dream come true. CFCs are stable, non-reactive, non-flammable, non-toxic and odorless compounds, which had many applications as propellant gases or as coolants and fire suppression agents. They were used in many things, from fire extinguishers to refrigeration units and hairspray cans, they were used to clean electronic components, to make the bubbles in polystyrene foam and in many other applications.

As their name suggests, CFCs are compounds of various combinations of chlorine, fluorine and carbon atoms, the most common being trichlorofluoromethane (CFC-11) and dichlorodifluoromethane (CFC-12). Unfortunately for us, CFCs have not proved as stable as we hoped. While they are stable at lower altitudes, once they ascend into the stratosphere, they are subject to high-energy bombardment by incoming UV radiation from the sun. This intense high-energy bombardment liberates chlorine radicals (highly reactive chlorine atoms) from the CFCs. These chlorine radicals 'attack' the ozone molecules, breaking them up into oxygen molecules and free oxygen radicals, which in turn break more ozone down into oxygen molecules. A single chlorine radical which initiates the reaction can effectively convert up to 100,000 ozone molecules into oxygen in its "lifetime". As if this is not bad enough, CFCs are also important greenhouse gases.

Bromine radicals are even more ozone-destructive than chlorine radicals - each bromine radical can destroy hundreds of times more ozone molecules than a chlorine radical. Bromine-containing compounds can be found in such equipment as halon fire extinguishers.

Substitutes are available for most of the uses of CFCs. For example, scientists have developed hydrofluorocarbons (HFCs) that substitute hydrogen atoms for the chlorine atoms in CFCs, and hydrochlorofluorocarbons (HCFCs) that substitute hydrogen atoms for some of the chlorine atoms of CFCs. Both HFCs and HCFCs decompose more rapidly than CFCs in the atmosphere - on average 2 - 20 years as compared to 20 - 100 years for standard CFCs. Also, their ozone depletion potential is only 2 - 10 percent of conventional CFCs and they would contribute 90% less per kilogram to greenhouse warming than currently used CFCs. However, it should be mentioned that HCFCs do still contain some chlorine atoms and these are still ozone destroyers.

The only way to decrease the rate of ozone loss significantly is to substantially reduce the use of CFCs and related compounds. In 1989, delegates from 82 countries signed the Helsinki Protocol, which pledged in principle to phase out the use and production of the five CFCs most strongly implicated in global ozone depletion, by the year 2000, if substitutes were available by then. It was also agreed that there was a need to phase out or reduce the use of other ozone depleting substances such as halons, carbon tetrachloride, methylene chloride and the HCFCs now being used as CFC substitutes - however, no action was taken on this agreement. According to the US EPA, overall concentrations of chlorine from these compounds in the stratosphere could double, triple or quadruple in the next century even if CFCs are completely phased out. Even if all ozone-depleting substances were banned, it would still take Earth over 100 years to recover from the current ozone depletion. It is a sobering picture.

Global Warming and the Greenhouse Effect

People often confuse these two terms and use them to refer to the same thing. The fact is, global warming is caused by the greenhouse effect. We may not have noticed it in our day-to-day lives apart from complaining that the days are warmer than before, but the Earth's average yearly temperature has been slowly but steadily increasing over the last century or so since the industrial revolution. Monitoring stations on Mauna Loa in Hawaii have been recording increasing global temperatures for many years.

The greenhouse effect itself is a necessary mechanism for the survival of life on Earth. Without the greenhouse effect, temperatures on Earth would be around -10°C, too cold for most life on the planet. The trouble is the pollutants entering the atmosphere, largely as a result of man's activities. In carrying out agriculture and industry, humanity has released countless billions of tons of pollutants into the atmosphere. Among them are the chief contributors to global warming - carbon dioxide, CO_2 , and methane, CH_4.

1. Carbon dioxide

All living, aerobic organisms produce CO_2 as a by-product of cell respiration. CO_2 is an integral part of the atmospheric mixture. However, due to the increasing human population, and our increasing use of fossil fuels, the amount of CO_2 in the atmosphere is increasing by about 0.5% each year.

Carbon dioxide molecules absorb infrared radiation (or heat energy) and prevent its loss to space. While this insulating effect is highly desirable, as was stated above, when the concentration of carbon dioxide increases to a higher level, more and more heat energy is trapped within Earth's atmosphere. The effect is a gradual increase in global temperature. A good analogy of this would be to imagine yourself sitting in your car in the sunlight, with the air-conditioning turned off and all the windows wound up. Although the increase in Earth's temperature is nowhere as dramatic as in the confined space of the car, this is due to the much greater volume of Earth's atmosphere. Should nothing be done, it is conceivable that future generations will live in a very much warmer world than we do.

The main source of anthropogenic, that is human-based, carbon emissions is the burning of fossil fuels. Each year billions of tons of CO_2 are released into the atmosphere from fossil fuel use. Another major problem is that we are also removing the capacity of Earth to absorb CO_2 from the atmosphere. Tropical rainforests are a major CO_2 sink, yet each year millions of acres of tropical rainforest are cleared for agriculture. To make a bad picture even worse, the rainforest is generally cleared by burning, which releases even more CO_2 into the atmosphere. The only other significant CO_2 sink is the ocean - and its capacity as a sink is limited to the top 100 metres or so of water - below this, there is not much mixing, so the concentration of CO_2 in the oceans remains fairly constant. Scientists today agree that atmospheric CO_2 has increased by about 25% since 1860.

2. Methane

The other greenhouse gas of appreciable importance is methane, or CH_4. Concentrations of methane in the troposphere have doubled in the last 250 years. This increase can be attributed to man's activities such as agriculture. The huge increase in numbers of ruminants farmed for meat, milk and hides has led to a proportional increase in the amount of CH_4 released into the atmosphere. All ruminants, i.e. animals that have four chambers in their stomachs, produce methane as a by-product of cellulose digestion by methanogenic bacteria under anaerobic conditions in their digestive tracts.

Methane can be removed from the atmosphere in several ways, one of which is fairly useful - methane can react with hydroxyl radicals in the troposphere to produce ozone. Various soil bacteria are also capable of breaking down methane. On the whole however, the concentration of methane in the atmosphere is growing by more than 1% annually, double the rate of CO_2 increase. While the concentration of CH_4 in the atmosphere is small compared to the concentration of CO_2 , it has a disproportionately large effect due to the fact that each molecule of methane absorbs infrared radiation 20 times more effectively than a molecule of CO_2.

The Effects of Global Warming

The most talked about consequence of global warming is the rise in sea level associated with the increase in global temperatures. The increased temperatures would lead to a partial melting of the polar ice caps, which would in turn lead to rising sea levels. Sea levels have been on the rise for the last century. Along the Atlantic coast of the United States, the sea level has risen about 30 centimeters. The rise in sea levels is due in part to the subsiding of coastal land as well as increased temperatures, which not only melt ice but cause sea water to expand. As an example of what may happen, an increase of 5 meters in sea level would affect 40% of Florida's population, putting the cities of Miami, St. Petersburg and Jacksonville under water. It would also put many islands under water and submerge many of the existing coral reefs and atolls. Although new reefs could emerge, the loss of the existing ones would still be felt.

The impact on coastal wetlands would be more noticeable. As sea levels rise, coastal mangroves, swamps, deltas and estuaries would be inundated, reducing the habitat for all species of flora and fauna adapted to these environments. The loss of diversity would be serious and irreplaceable. Plants and animals would likely suffer greatly as rapidly changing climatic conditions force animals and plants to try to adapt. Rapid climatic change is one of the theories of what caused the extinction of the dinosaurs, and it is not inconceivable that another round of mass extinction would follow if global weather patterns change rapidly.

Another serious social and economic concern is the shifting weather patterns that would be caused by an increase in global temperatures. These changing patterns would shift the areas suitable for cultivation northwards in the Northern Hemisphere. Most of the world's food is grown in a band of land with a temperate climate that stretches across North America, Europe and Asia. As temperatures increase, these areas would become unsuitable for cultivation of the current food crops. New areas would likely become suitable for cultivation. However, this is a matter of conjecture, not a certainty.

Noise Pollution

When people think of air pollution they generally think of smoke or toxic gases. Not many people realize that noise is also a form of air pollution. Most of us take the presence of noise for granted. Noise is unwanted sound, which is composed of moving pressure waves in the air. These pressure waves cause our ear drums to vibrate, and our brains interpret these vibrations into sounds.

Noise pollution is sound we do not desire. It can range from the quiet hum of air conditions in the office to the roar of jet engines. The effects on people are less noticeable than some other forms of air pollution, for example, carbon dioxide, but are there none the less. Noise causes psychological problems such as inattention and stress, and causes progressive hearing loss, which can occur quite rapidly in modern societies.

Noise control regulations are becoming commonplace. Most are designed to protect workers working in environments where a high level of background noise is unavoidable, such as in the steel industry, or at airport runways.

Indoor Air Pollution

Tobacco smoke, fungi and allergens from air conditioners, volatile organic compounds from new furniture and carpets, formaldehyde from building materials, carbon monoxide from burning, radon from underground uranium, and asbestos from old floor tiles and stove installations among others combine to make indoor air more polluted than air outdoors. The main factor behind this occurrence is the lack of ventilation in most buildings. Once pollutants enter or are generated in a building, they tend to remain in the air for long periods of time. Most buildings are not designed with proper air circulation facilities. Unfortunately, good ventilation is the only way to get rid of indoor air pollution.

Reducing Air Pollution

Almost all of us agree that something must be done to reduce air pollution. Unfortunately, most of us disagree on who should take the first step. The industrialized nations point to the developing nations and say that they should curtail their use of polluting substances, forgetting that most of the air pollution is due to industries in their countries. Developing countries point out that industrialized nations should lead the way in curbing air pollution and give time to the developing nations to reach the status of developed nations before they go about reducing air pollution.

No matter what the argument, one fact is clear. If we do not do something to significantly reduce air pollution, within this generation, the future of our children, and their children, looks grim. It is in our power to reuse significantly the amount of pollution that goes into the atmosphere. There are many choices available to us, for instance, we could take public transportation to work rather than driving; we could use fans in our bedrooms, rather than air-conditioners; we could give up smoking; we could stop burning forests - the list of choices goes on and on. It is not too much to say that the future is in our hands. Let us hope that it is in good ones.

WATER POLLUTION AND ITS CONTROL

Water Pollution

Water pollution is perhaps the most serious pollution threat any particular individual faces. The human body is over 75% water, just as the Earth's surface is over 75% water. Water pollution is defined as the introduction into fresh or ocean water of chemical, physical or biological material that degrades the quality of the water and affects the organisms living in it. At present, a person would be hard pressed to find any body of water that is unaffected in some way or another by human pollutants. Even supposedly pristine mountain streams are affected by air pollutants, for example, acid precipitation. The human population explosion and the advent of industry have severely degraded large water bodies over much of the world. 80% of the lakes in Sweden have no fish life because they have become too acidic. In the 1960s the Cuyahoga river running through Cleveland contained such a load of flammable pollutants from the city's industries that the surface of the river actually caught fire and destroyed 3 bridges. Water pollution is an immediate threat to the quality of human life. As such, we must understand water pollution if we hope to enhance the quality of life for, not just ourselves, but all other forms of life that depend on water for survival.

Categories of Water Pollutants

Water pollutants can be divided into 4 main categories:

1. Pathogens or disease-carrying agents. These are organisms that cause disease and live in the water or have water as the major carrying agent. Pollution with pathogens is usually caused by human sewage or animal manure/carcasses getting into the water.

2. Nutrients and oxygen consuming waste. Biodegradable organic matter includes the remains of plants and animals, including feces, leaves, wood waste, fat and debris from food processing plants. These substances are broken down by decomposers into mineral nutrients that plants take up and can consume a lot of oxygen in the process.

3. Suspended solids and other physical agents. Physical agents are things like heat and suspended solids, such as soil, that can destroy the usefulness of water if present in large quantities.

4. Toxic chemicals. These are chemicals that are poisonous to organisms. They include metals such as lead and mercury, organic compounds such as some pesticides and waste products of the petrochemical industry and radioactive waste.

Pathogens and Disease-carrying Organisms

Every so often we read about outbreaks of cholera, typhus or diphtheria affecting people in towns or neighbourhoods. The source of the outbreak can often be traced to contaminated water supplies, or food containing contaminated water. Although a small amount of pathogens are present in normal circumstances, problems arise when the amount of pathogenic organisms rises above a certain threshold. Once this happens, the water source is no longer safe for consumption.

Some biological pollutants contain pathogens that have been excreted by sick people and animals. This occurs mainly in less developed nations where inadequate treatment of sewage leads to large quantities of bacteria and organisms being discharged into the local waterways. As there is usually inadequate access to clean water in these nations, people and livestock end up taking water directly from the contaminated water bodies, and often fall victim to the pathogens in the water. They in turn add their contaminated waste to the land and water, where it inevitably ends up back in the water system for consumption by people further downstream.

Nutrients

Although nutrients are not normally viewed as pollutants, the extent of artificial fertilizer use in agriculture and the incorporation of mineral nutrients in domestic consumer products such as detergents, has led to an over-abundance of plant nutrients in most major waterways. The reason for this is that these nutrients are being poured into the waterways at a much higher rate than they can be utilised by the plants found in the water bodies. This leads to problems, which we will discuss later.

One of the main contributors to nutrient pollution is domestic sewage. Sewage is a combination of water from toilets, sinks and other domestic sources that passes into a series of pipes and is channeled to a treatment plant for processing to reduce the quantity of harmful organisms in the sewage. At least, this is the case in most countries. In poor countries, sewage is often channeled in its untreated form into the nearest river.

Nutrients and eutrophication. Detergents and fertilizers containing phosphate are important sources of nutrient pollution. As mentioned earlier in this chapter, phosphate is the most common limiting factor of plant growth, due to its scarcity in most natural environments. As phosphate from anthropogenic sources flow into the waterways, aquatic plants experience a bonanza of this scarce nutrient and can grow rapidly. In and of itself, this would not be a serious problem, especially if the continuing influx of phosphate rich water is small. Unfortunately, serious problems can and do arise when large quantities of nutrients continue to flow into a lake or river.

Sources of nutrients include sewage, phosphate-containing detergents, feedlot waste, fertiliser runoff and industries such as paper mills, meat-packing plants and industries. These sources often add nutrients to the water continuously, in which case, eutrophication proceeds rapidly.

Eutrophication refers to the process by which a body of water becomes so rich in nutrients that enormous quantities of blue-green algae are able to grow. Once this occurs, the huge numbers of algae cause the gradual loss, by lack of sunlight, of the entire plant community in the water body. The reason for this is that the algae, being single-celled or simple organisms, can absorb and utilise the nutrients in the water at a much greater rate than complex plants. As plants begin to die, they are broken down by decomposers. The process of decomposition uses up the dissolved oxygen in the water, resulting in very low dissolved oxygen levels. Conditions can even become anoxic at the bottom of the water body. Apart from this problem, the vast numbers of algae also excrete prodigious quantities of cellular waste that contribute to the progressive unsuitability of the water as a medium to sustain life. Most living organisms cannot tolerate these conditions. Those that can leave will do so, those that cannot leave, for example, plants or organisms in a closed water body such as a pool, will die.

Suspended Solids and Other Physical Agents

Suspended solids refer to the small particles of clay, silt and other components of soil that are washed into the water by rain or other forms of precipitation, or enter the water by other means. These particles are small enough that the water current, or movement, keeps them suspended in the water column, i.e. they do not sink to the bottom. Small quantities of suspended solids are a natural part of the water body. In large quantities however, such as are found in areas prone to heavy soil erosion, pollution with suspended solids becomes extremely evident.

Problems that arise from excessive siltation include siltation of dams and reservoirs, clogging of filters at water intake points, blocked turbines at hydroelectric plants and other problems. The impact on aquatic organisms is even more severe. High silt loads in the water tend to bury benthic (bottom dwelling) organisms such as shellfish, clog the gills of fish and other organisms with gills and block out the sunlight. This last problem can, as in the case with advanced eutrophication, result in the death of aquatic plants, as photosynthesis is prevented due to the lack of sufficient sunlight.

Another form of physical pollution that occurs quite often, but does not get as much notice (mainly due to there being no obvious change in the water condition, such as a change in colour or turbidity) is thermal pollution. This is a site-specific pollution, meaning it occurs only in certain places, most notably near the coolant release points of power plants located near the water. These power plants take in large quantities of cool water as coolants for their boilers and other systems, then discharge this water back into the river or lake. The temperature of the water being released is usually several degrees Celsius higher than the surrounding water. This leads to the formation of a zone of warmer water being formed in which the native organisms may have a difficult time surviving. The warmer water may not be suitable for the organisms originally found in the area, and where possible, these organisms will migrate to more suitable areas. Those organisms that cannot migrate will either adapt to the new conditions or perish. New organisms will take their place. In one occasion, the thermal pollution from a power plant resulted in the area becoming a rich breeding ground for the blood cockle *(Anadara granosa)*, which helped boost the income of the local fishing folk. Most of the time however, the consequences of thermal pollution are less desirable. The increased warmth also leads to an increase in the productivity of the area, notably an increase in the activity of decomposers. This can lead to a decrease in the levels of dissolved oxygen in the water, especially as increased water temperature means the dissolved oxygen content of the water will be lower.

Toxic Chemicals

Although toxic chemicals were covered in some detail in the earlier section, one additional factor is worth discussing; dilution. When toxic chemicals enter a body of water such as a river or lake, the water dilutes them. If the water is present in sufficient quantities, and the quantity of toxin is not great, it is possible that there will be relatively few side effects. Increased current flow rate also increases dilution, making spillage of small amounts of toxins into a fast flowing river less likely to have serious consequences than if the spill occurred in a slow flowing river (assuming the rivers are of the same width and depth).

Sewage Treatment

A sewage treatment plant is designed to encourage the same processes that occur when wastes decompose in a lake or river. The process imitates nature by encouraging the decomposition of sewage material.

Primary Treatment

Basically, primary treatment consists of filtering out the larger objects and other solid matter. The raw sewage is passed through a series of screens to filter out the larger objects, such as plastic toys, jewelry and toothbrushes that should never have been flushed down the toilet in the first place. The sewage then proceeds to settling tanks, where the flow rate is extremely slow, around 1 - 2 metres per hour. This allows as much as 80% of the solid matter to settle to the bottom as sludge. The liquid from the settling tanks may then flow into a chlorinator, where chlorine is added as an anti-bacterial agent. Although the treated water is now relatively bacteria free, it still contains approximately 40% of its solids and 70% of its organic material. Meanwhile, the sludge is treated with anaerobic organisms in a sludge digester, where it is partially broken down, releasing such by-products as methane gas.

Some cities in Southern California have implemented advanced primary treatment in their sewage treatment plants. These plants work by introducing various chemicals to the sewage to cause greater quantities of suspended solids to precipitate out of the solution. At present, hydrocarbon polymers mixed with ferric (iron) chloride is the compound of choce. The polymers are electrically charged so that they will attract and bind with charged particles in the solution, causing them to precipitate. This process does actually reduce the quantity of suspended solids in the waste water produced, but at the risk of adding potentially toxic chemicals to the water in the process.

Secondary Treatment

Secondary treatment starts with the products of primary treatment and utilises aerobic decomposers to reduce the volume of the sludge and the amount of organic matter in the waste water. The liquid from primary treatment is pumped into an aeration tank, where air is bubbled into the liquid to permit aerobic decomposers to do their work. The water is then piped into a settling tank, where the activated sludge settles out of it. This sludge is then recycled into the aeration tank. The volume of the sludge produced is significantly reduced by the action of the aerobic decomposers.

An alternative method of secondary treatment is to spray the fluid from primary treatment onto trickling filters by means of a rotating nozzle that serves to add oxygen from the air. Trickling filters are actually beds of gravel where many species of aerobic decomposers live and work, including bacteria, fungi, protists, fly larvae and worms. After passing through trickling filters or aeration tanks, the fluid is again passed into a settling tank, where any remaining solid matter settles out. The water produced by secondary treatment contains little organic matter and has also lost about half its inorganic nutrients. It is then chlorinated and subsequently released.

Chlorination. The most common anti bacterial and anti-algal agent in use for treating water is chlorine. The trouble with chlorine is that it is very toxic to fish and it reacts with various organic molecules to form compounds that cause cancer and birth defects in humans. The concentration of chlorine in most water supplies at the moment does not seem to be a major threat to human health, but we cannot afford to let the levels of chlorine compounds in drinking water rise much further.

Tertiary Treatment

This is rarely used unless the water produced by secondary treatment is destined for domestic use. Should this be the case, there are several alternatives available. Unfortunately, most of these involve the use of expensive chemicals in the treatment process. For example, the water may be treated with aluminum sulfate, which causes phosphates to precipitate, or the water may pass through a filter of activated charcoal, which absorbs many impurities.

One method of cleaning up sewage effluent that is gaining popularity is to channel the effluent through natural or manmade wetlands. This has several advantages over pouring the effluent into a river. Firstly, the effluent is purified as it trickles down through the soil, where it eventually reaches the ground water and helps to refill depleted aquifers. Second, the effluent may be used for irrigation, thereby saving precious water. In addition, any nutrients in the effluent will act as a fertilizer. The yield of crops on treated land increases markedly over land that is left untreated.

Disposing of Sludge

Sewage sludge often contains high concentrations of toxins, in particular, heavy metals and therefore must be treated as hazardous waste. It is usually incinerated and then buried in a secure landfill. The volume of sludge produced by most municipalities makes this method of treating sludge extremely expensive. To decrease the cost of disposing of sludge in this manner, many municipalities are investigating methods of reducing the toxicity of sludge, which would then allow them to use the sludge in a beneficial way. As sewage sludge is high in plant nutrients, its value as a cheap source of fertilizer is quite obvious. If the sludge could be effectively treated to reduce its toxicity, it would be a valuable source of cheap fertiliser for agricultural use. A novel use for sewage sludge is in the construction industry. In an interesting development, sludge is combined with clay to make bricks for use in construction. One can only imagine the thoughts of those buildings' inhabitants on finding out their walls are partly composed of processed feces! However, due to the necessity of finding new methods of disposing of sewage sludge, we can expect many more industries that consume sludge to develop in the near future as part of the solution to our solid waste problem.

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5 ISO 14001 ENVIRONMENTAL MANAGEMENT SYSTEM STANDARD - A QUALITY MANAGEMENT SYSTEM STANDARD FOR THE ENVIRONMENT

HUSSEIN RAHMAT

The need to manage the environment is more important today than it has ever been. Evidence shows that in the past lax control of activities have led to unacceptable environmental risks, resulting in industrial accidents such as the chemical accident at Bhopal (India 1984) and nuclear accidents at Three Mile Island (USA 1979) and Chernobyl (Ukraine 1986). All of these have caused tremendous public concern in addition to incalculable human suffering especially the Bhopal incident. Other accidents, such as the Exxon Valdez oil tanker accident (USA 1989) have caused environmental damage and the subsequent remedial action left questions as to the efficacy of the remedial action taken.

It is realized that industrial activities, desirable as they are for the welfare and economic development of the people of the world, contribute the most to pollution and environmental degradation. It is industrial activities therefore that need to be managed better so that they cause less pollution in the first instance rather than to have better technology to clean up the pollution afterwards. Another concept that industry in general needs to pursue is sustainable development. The World Commission on Environment and Development in its milestone 1987 report, "Our Common Future," (from the Brundtland Commission) emphasized the importance of environmental protection in the pursuit of sustainable development. Sustainable development could be defined in many ways. One good example is it "involves meeting the needs of the present without compromising the ability of future generations to meet their own needs."

In 1989, the United Nations identified the following as serious environmental issues:

1. The greenhouse effect and the accompanying change in world climate
2. The ozone layer depletion
3. Pollution of oceans and coastal waters
4. Acid rain and other trans-boundary pollution
5. Deforestation and loss of flora and fauna (biodiversity)
6. Management of hazardous wastes and contamination of drinking water

Today some of these concerns still remain.

Increasingly strict environmental legislation to control problems such as the above has become a fact of life particularly in North America and Europe. The United States of America has set itself on a very tight regime of laws and regulation dubbed as "command and control" whilst the European Union set out proposals for organizations to self-regulate their environmental performance and to continuously improve upon it. The European proposal has an added sting in that if few organizations are to take the challenge it will become mandatory, thus taking on the same regulatory flavor as that of the United States. This proposal was subsequently called the Eco Management and Audit Scheme (EMAS) Regulation. The proposal spawned such management systems as the British Standards BS 7750 Environmental Management System on which the ISO 14000 Environmental Management System was subsequently based.

At the same time industry worldwide began to realize that in the long run they need to voluntarily manage the environment better rather than rely on strict legislation. This has driven industrial organizations such as the International Chamber of Commerce (ICC) to launch the Business Charter for Sustainable Development. The Charter launched in April 1991 has sixteen principles founded on the concept of sustainable development:

1. Corporate priority
2. Integrated management
3. Process of improvement
4. Employee education
5. Prior assessment
6. Products and services
7. Customer advice
8. Facilities and operations
9. Research
10. Precautionary approach
11. Cooperation with contractors and suppliers
12. Emergency preparedness
13. Transfer of technology
14. Contribution to the common effort
15. Openness to concerns
16. Compliance and reporting

In ICC term "sustainable development" involves meeting the needs of the present without compromising the ability of future generations to meet their own needs. Economic growth provides the conditions in which protection of the environment can best be achieved, and environmental protection, in balance with other human goals, is necessary to achieve growth that is sustainable" – *from the introduction to International Chamber of Commerce (ICC) Business Charter for Sustainable Development*

The ICC can be reached on the internet by visiting their homepage at (http://www.iccwbo.org/)

There were other specific industry movements developed during this period. Some well-known examples are Responsible Care® adopted by the Chemical Manufacturers Association (CMA), and the Strategies for Today's Environmental Partnership (STEP) initiated by the American Petroleum Institute (API).

In 1988, the Chemical Manufacturers Association (CMA) launched Responsible Care® to respond to public concerns about the manufacture and use of chemicals.

The 6 Codes of Management Practices of Responsible Care® are:

1. The Community Awareness and Emergency Response Code
2. The Pollution Prevention Code
3. The Distribution Code
4. The Process Safety Code
5. The Employee Health and Safety Code
6. The Product Stewardship Code

The webpage for Chemical Manufacturers Association (CMA) Responsible Care is (http://www.cmahq.com/cmawebsite.nsf/pages/responsiblecare)

API's STEP became part of its organization Bye Law in 1990. The Mission and Guiding Principles on Environmental, Health and Safety for API members are the following:

1. To recognize and to respond to community concerns about our raw materials, products and operations

2. To operate our plants and facilities, and to handle our raw materials and products in a manner that protects the environment, and the safety and health of our employees and the public

3. To make safety, health and environmental considerations a priority in our planning, and our development of new products and processes

4. To advise promptly, appropriate officials, employees, customers and the public of information on significant industry-related safety, heath and environmental hazards, and to recommend protective measures

5. To counsel customers, transporters and others in the safe use, transportation and disposal of our raw materials, products and waste materials

6. To economically develop and produce natural resources and to conserve those resources by using energy efficiently

7. To extend knowledge by conducting or supporting research on the safety, health and environmental effects of our raw materials, products, processes and waste materials

8. To commit to reduce overall emission and waste generation

9. To work with others to resolve problems created by handling and disposal of hazardous substances from our operations

10. To participate with government and others in creating responsible laws, regulations and standards to safeguard the community, workplace and environment

11. To promote these principles and practices by sharing experiences and offering assistance to others who produce, handle, use, transport or dispose of similar raw materials, petroleum products and wastes

The webpage for American Petroleum Institute STEP is (http://www.api.org/step/)

Non-industry specific organizations also formed groups to promote the better management of the environment. One such example is the Coalition for Environmentally Responsible Economies (CERES). CERES, a non-profit membership organization, was formed in 1989. It brought fifteen major U.S. environmental groups together with an array of socially responsible investors, environmental groups, religious organizations, public pension trustees and public interest groups. They promote responsible corporate activity for a safe and sustainable future for our planet. Their basic credo is based on the following principles (earlier known as the Valdez Principles):

1. Protection of the Biosphere
2. Sustainable Use of Natural Resources
3. Reduction and Disposal of Wastes
4. Energy Conservation
5. Risk Reduction
6. Safe Products and Services
7. Environmental Restoration
8. Informing the Public
9. Management Commitment
10. Audits and Reports

CERES can be reached on the internet at their website (http://www.ceres.org/)

There are many similarities between the guiding principles among the various initiatives except that those initiatives from specific industries attempt to be more comprehensive in integrating the need for excellence in occupational safety for employees and the workplace as well.

In 1992 the United Nations organized the Earth Summit in Rio de Janeiro. The Summit lead to the publication of a blueprint - AGENDA 21 - calling for a global partnership, charting the way forward to achieving sustainable development, improving efficiency of use of resources, minimizing waste, protecting human health, and protecting the environment at large. The document was accepted by 179 governments. The Summit also led to the formation of the United Nations Council for Sustainable Development closely followed by the World Business Council for Sustainable Development (WBCSD). The WBCSD can be reached on the internet at their website (http://www.wbcsd.ch/)

At the international level there were responses by world agencies and organizations, such as World Trade Organization (WTO) and the Geneva, Switzerland based International Organization for Standardization (ISO), to help protect the environment. on a world scale and in a coordinated manner. In response to industrial and business sector demands and as an after-effect of the Earth Summit, ISO action was translated into the development of ISO 14000 series of Environmental Management System (EMS) standards. The development of ISO 14000 was greatly helped by the experience gained from BS 7750 Environmental Management System issued in March 1992 by the British Standards Institution (BSI) and the 200 or so organizations that were certified to that standard by 1993.

The aim of ISO 14000 Environmental Management System is for organizations to demonstrate their commitment to continual improvement of their environmental performance through prevention of pollution, compliance to regulations and reduction of waste. It is designed to be a generic management standard meant for implementation by an organization of any size in any industry and in any country around the world.

Today it is a widely accepted international standard. Among its attractions is that it gives an organization the opportunity to practice self-regulation through its built-in regulation and best-practice compliance mechanism and continual improvements procedures. The result is that its stakeholders, the government and other interested parties, view the organization favorably with the assurance that it provides. At the same time, this effort reduces the organizations' exposure and liability to litigation and the cost of clean-ups or remediation. The most attractive benefit of all is that it gives an organization an opportunity to review its practices with the aim of reducing wastes in general. This benefit arises because when an organization succeeds in generating less waste, less raw materials are used. This in the end translates into lower cost of production giving the organization a competitive advantage in the market place. Oftentimes reduction of waste generation is arrived at through recovery of waste materials. Many organizations were surprised that the materials recovered are valuable products in their own right or ones which could be used in other ways to generate additional revenue. Good environmental management can thus mean good business for many organizations.

To sum-up the idea that the environment is good business is a quote from Gustav Krause, the Minister of the Environment, Brazil when he officiated an ISO TC207 meeting. He said:

> "Reducing costs in order to eliminate waste, developing clean and cheap technologies and recycling raw materials, are more than principles of environmental management – they are pre-requisites for survival."

To know more about ISO 14000 visit the official ISO/TC 207 website. This website is the home of the International Organization for Standardization's (ISO) Technical Committee 207 on Environmental Management—the committee responsible for developing the ISO 14000 series of standards and guidance documents. The secretariat of ISO/TC 207 is held by the Standards Council of Canada (SCC) and administered by the Canadian Standards Association (CSA) (http://www.tc207.org/home/index.html). An alternative website is the American National Standards Institute (ANSI) On-Line's section providing general information and services related to the ISO 14000 environmental management standards (http://web.ansi.org/public/iso14000).

THE VERSATILE ISO 14000 ENVIRONMENTAL MANAGEMENT SYSTEM

Right from the start the ISO 14000 Environmental Management System was meant to be a system that could be integrated into the mainstream of business management. Therefore it needs to be universal from that aspect. At the time when ISO 14000 was proposed there were already concepts relating to how one could manage an organization with the assurance of quality for its customers and management effectiveness for its other stakeholders. One very popular system was ISO 9000 Quality Management System, which took the world by storm. Another was the Total Quality Management (TQM) concept which spearheaded the Japanese industrial miracle. The amalgam of these two concepts resulted in ISO 14000 being an environmental quality management system that provides a framework for sustainable development that is easily integrated into main stream management systems such as quality management system and occupational health and safety management systems.

Many organizations have no difficulties in integrating ISO 9000 Quality Management System and the ISO 14000 Environmental Management System as they are compatible. The Plan Do Check and Act (PDCA) concept that will be explained later forms the basis of ISO 14000. This makes it versatile and amenable to adaptation to other management systems such as occupational safety and health management system. Indeed the British Standard BS 8800 Guide on Occupational Safety and Health Management System is entirely compatible with ISO 14000.

The ISO 9000 movement developed the concept of the need for a supplier to have a management system to assure quality for direct customers. Much legislation, especially in the area of safety including Malaysia's own Occupational and Safety Act:1994 stipulates management arrangement as a requirement. In the United States of America the Occupational Safety and Health Administration (OSHA) requires the establishment of a management system to fulfil the OSHA CFR 1910.199 legislation for safety. The auto industry requires vendors to conform to a Quality Management System (QMS 9000) and so do other similar organizations in the United Kingdom and other countries. Additionally the various industry environmental initiatives such as CMA's Responsible Care for the chemical industry and API's STEP for the petroleum industry require verifiable management systems.

What can a management system do to ensure that management is effective? A system is useful when one is faced with complexity in pursuing one's objectives or goals. The complexity can be derived from the many processes or activities that must be kept within their boundaries or limits, the enormous amount of information that needs to be processed, the involvement of many players or elements and their varying needs and finally the interaction with externalities. A systematic approach is necessary to divide a large complex system into sub-systems with each subsystem being managed effectively and in the end the whole system is amenable to management.

One must admit that to manage the environment is a complex affair. The environment has many unknowns and managers have to struggle with the many factors that have to considered. Some of these are the socio-economic and political issues of sustainable development, the considerations of technological availability and cost of operation and production, competition in the market place and the various needs of stakeholders including the neighboring community, non-governmental environmental organizations, legislators, shareholders and finally customers. This is surely more than a quality product management issue alone.

The other concept embodied in ISO 14000 is the idea of Total Quality Management (TQM). The basic aim of TQM is to reduce and eliminate defect and waste in manufacturing. The outcome of this effort is to lower cost of production and to satisfy the needs of customers, owners and other stakeholders with whom the organization interacts.

TQM began with the teachings of "quality gurus" such as Deming. Deming stressed that management should carry out its business using the cycle of Plan, Do, Check and Act (PDCA). The PDCA cycle can be put in layman's language as a procedure which requires organizations to ask themselves the following questions:

1. Where do you want to go?
2. Where are you now?
3. What is the gap between where you are and where you want to go?
4. How do you close the gap and get there?
5. What do you need to close the gap and to go there?
6. How do you know you have arrived?

To facilitate that, process management has to have in place a system of

1. management actions,
2. operating procedures,
3. documentation & record keeping,
4. organizational structure, and
5. resources.

The management model adopted by ISO 14000 is that of Deming PDCA. The ISO 14001 Environmental Management System Specification is structured along these framework and, as stated in ISO 14004 is guided by the following principles:

Principle 1 – Commitment and Policy
Principle 2 – Planning
Principle 3 – Implementation
Principle 4 – Measurement and Evaluation
Principle 5 – Review and Improvement

The actual embodiment of TQM in ISO 14000 is in the principle that commitment and leadership must come from the top. Like TQM it requires management backing in providing resources, and clarity of objectives to support it. It also relies on the support and feedback of employees at all levels.

Further, ISO 14000 requires that all parts of the organization to be involved in the process of identifying risks and opportunities be involved in planning and execution of the plans and above all in providing feedback for continual improvement. Continual improvement is part and parcel of ISO 14000. Mechanisms for this are provided through audits, records, corrective and preventive action and management review. Along the way, corrective actions are made by monitoring performance through measurements and analysis of facts of the situation. Root causes of defects and nonconformance are the basis for correction and improvement. Employees are to be trained. Benchmarks are provided to compare environmental performance against what is desired. The benchmarks are environmental performance indicators provided as part of plans and targets. These plans and targets are, in turn, to be according to the organization's policy and should be in consonance with the customers of the environment, which are interested parties inclusive of the government. These are the benchmarks of TQM.

ISO 14000 Environmental Management System could and should be integrated with mainstream management activities. This is because of the requirements of planning for an environmental program, the resources to be provided for it in terms of budget and personnel and finally the fact that employees can affect the environment with their actions and behavior.

In the Introduction to ISO 14004 the remark was made that "the design of an EMS is an ongoing and interactive process. The structure, responsibilities, practices, procedures, processes and resources for implementing environmental policies, objectives, and targets can be coordinated with existing efforts in other areas (e.g. operations, finance, quality, occupational health and safety)". It has been mentioned earlier that ISO 14000 Environmental Management System could easily be integrated with ISO 9000. This is not surprising as when ISO 14000 was drafted ISO 9000 already existed and the standard was kept in mind in the ISO 14000 drafting process. As a result the two standards share many common elements although the PDCA concept is not as well pronounced in ISO 9000.

The ability of ISO 14000 to address the issue of occupational safety and health has also been mentioned earlier in the context of BS 8800 Guide to Occupational Safety and Health Management System. This fact has been recognized by the drafters of ISO 14000 themselves. The introduction to ISO 14001 states that whilst the "International Standard is not intended to address, and does not include requirements for aspects of occupational health and safety management; however it does not seek to discourage an organization from developing integration of such management system elements".

The integration of occupational safety and health and the environment is easy. The two systems have approaches and many managing elements that are similar. The two systems always begin with the identification of hazards, their assessment and measures to manage and control them. In the case of the environment, ISO 14000 expects organizations to identify impacts of the organization's products, services and activities taking the legal and other requirements into account and from then on to establish targets and objectives and environmental programs. The management of hazards includes documentation, operational control, surveillance, corrective actions and reviews. These steps and many others are parallel to what needs to be done in occupational safety and health administration.

As a matter of fact, the area of environment in the workplace overlaps considerably with that of the larger environment. Occupational safety and health regulations regarding the environment in the work place could be applicable to the larger environment except for the matter of scale that extends beyond the confines of the work place.

The ISO 14000 Environmental Management System has received wide acceptance not only by the industry but also by some governments. This is partly because industry badly needs such a management system and also because it is a good system that satisfies many needs. By all accounts, ISO 14000 Environmental Management System standards adoption rate seems to surpass that of the ISO 9000 by far.

In summary, ISO 14000 Environmental Management System is a quality management system applied to the management of the environment. Some aspects of TQM are incorporated. Like ISO 9000 Quality Management System, ISO 14000 is not a product or a performance standard and must never be to misconstrued as being tied with any products, services or activities. The ISO organization is now vigilant on this point as there have been some abuses in this regard in the ISO 9000 arena. ISO 14000 is meant to be an international standard that is suitable for any size organization anywhere in the world. That being so, it does not specify any performance standards on emission, effluence and the like. This is the duty of legislation in the resident country of the organization. ISO 14000 organization, in turn, is duty bound according to the Standard to obey this. The fact that ISO 14000 is voluntary and meant to be self-regulating does not absolve an organization from not doing so. Whilst the standard does not mandate zero emission the organization is duty bound to move in that direction as part of the process of establishing the system. An organization is to identify all aspects and, in time, it must improve its performance, as part of the System. The System does not mandate immediate use of the best available technology at all costs. The organization is to balance economics with environmental care. In ISO 14000 the organization finds a framework for managing significant environmental aspects it can control and over which it can be expected to have an influence. The Standard represents a shift to pro-active thinking and acting and a "paradigm shift" toward prevention rather than cure. Thus the Standard is a tool for sustainable development.

ENVIRONMENTAL MANAGEMENT SYSTEM - OVERVIEW OF ELEMENTS

The ISO 14000 Environmental Management System is a management system that is compatible with the ISO 9000 Quality Management System. Many of their elements are similar in concept. However the ISO 14000 Environmental Management System is based on the Plan, Do, Check and Act management model attributed to Deming. The ISO 14000 system is guided by the five principles stated earlier.

In the following pages the seventeen elements of the standard are summarized.

Principle 1 – Commitment and Policy

1. *Environmental Policy* — Develop a statement of your organization's commitment to the environment. Use this policy as a framework for planning and action.

Principle 2 – Planning

2. *Environmental Aspects* — Identify environmental attributes of your products, activities and services. Determine those that could have significant impacts on the environment.
3. *Legal and other Requirements* — Identify and ensure access to relevant laws and regulations (and other requirements to which your organization adheres).
4. *Objectives and Targets* — Establish environmental goals for your organization, in line with your policy, environmental impacts, views of interested parties and other factors.
5. *Environmental Management Programs* — Plan actions to achieve objectives and targets.

Principle 3 – Implementation

6. *Structure and Responsibility* — Establish roles and responsibilities and provide resources.
7. *Training, Awareness and Competence* — Ensure that your employees are trained and capable of carrying out their environmental responsibilities.
8. *Communication* — Establish processes for internal and external communications on environmental management issues.
9. *EMS Documentation* — Maintain information on your EMS and related documents.
10. *Document Control* — Ensure effective management of procedures and other system documents.
11. *Operational Control* — Identify, plan and manage your operations and activities in line with your policy, objectives and targets.
12. *Emergency Preparedness and Response* - Identify potential emergencies and develop procedures for preventing and responding to them.

Principle 4 – Measurement and Evaluation

13. *Monitoring and Measurement* — Monitor key activities and track performance.
14. *Nonconformance and Corrective and Preventive Action* — Identify and correct problems and prevent recurrences.
15. *Records* — Keep adequate records of EMS performance.
16. *EMS Audits* — Periodically verify that your EMS is operating as intended.

Principle 5 – Review and Improvement

17. *Management Reviews* — Periodically review your EMS with an eye to continual improvement.

ENVIRONMENTAL POLICY (CLAUSE 4.2)

The element of Environmental policy is to be read together with clause from the following documents:

ISO 14004	4.1	Commitment and Policy.
ISO 14004	4.1.1	General.
ISO 14004	4.1.2	Top Management Commitment and Leadership.
ISO 14004	4.1.3	Initial Environmental Review.
ISO 14004	4.1.4	Environmental Policy.

The intent of this element is to ensure that the top management of the organization defines and declares its commitment to an environmental policy that seeks to continually improve its performance on environmental conservation that is appropriate for its activities. It is a statement of its principles and intentions that

1. indicates the organization's long-term direction,
2. establishes a framework for action for all its employees, and
3. provides visible evidence of top management support of the organization's efforts on the environment.

The performance of the organization will be judged against the published environmental policy. ISO 14000 Environmental Management System requires that the overall environmental programs be based on the policy statement. Therefore the policy should be formulated to express goal or vision of the organization, its core values such as care for the environment and the following three key commitments:

1. Focus on environmental protection including sustainable development and environmental good practices
2. Focus on continual improvement, reduction of raw materials use and generation of waste; replacement of hazardous chemicals used with safer ones or elimination of them altogether; reuse and recycling of raw materials
3. Compliance with and support of the law, international environmental initiatives and industry guidelines

Everyone in the organization should understand the environmental policy and what is expected of him or her in order to achieve the organization's goals.

Developing the Policy

The environmental policy should be initiated, developed, and actively supported at the highest levels of the organization. The policy should be integrated into the enterprise's overall business strategy. It must also be relevant to the activities, products and services of the enterprise and appropriate to the location of the organization. It should also be compatible with the organization's other policies such as its quality, occupational safety and health policies if these exist. Many organizations integrate Occupational Health and Safety policy with environmental (HSE) policy. The three have many common characteristics such as the control of chemical acquisition, transportation, handling and storage, inspection procedures, incident investigation, corrective action, emergency response, training, education and auditing. Some even manage HSE and quality under the same function. After all, HSE management is management of quality.

Sources of Input for Policy Development

The organization's own Initial Environmental Assessment, if this was carried out, is obviously one good source of input for policy development. Others include the organization's own values and beliefs, business strategy and its strategic plans. Any existing statements on environmental aspects, mission statements, old policies, and policies in other areas of the enterprise e.g. quality, occupational health and safety could be incorporated. It is best to take into account the views of stakeholders such as a particular community's concern for water pollution or emissions to its immediate surrounding.

Statements of environmental principles by external groups e.g. Business Council for Sustainable Development, CERES, Responsible Care, STEPS and other written standards could be incorporated. Special local or regional conditions can be other sources of input to policy development. For example, if one operates in an environmentally sensitive area such as wetland or wildlife sanctuary, the concern for conservation there could provide material for the policy statement.

The environmental policy statement should be concise (one to two pages), written for a wide audience including the layman and in plain language which is free of environmental and technical jargon. The statement is then reviewed at different levels within the organization.

In summary the intent, goals and objectives of the policy should be SMART:

Simple

Measurable

Achievable

Reasonable

Tractable

Implementing the Policy

From the policy, develop detailed and measurable targets and objectives. Then, translate the policy into action through an environmental program. In the program identify priorities, employee responsibilities and allocation of resources. These will be discussed further with the other elements of the Environmental Management System.

Publishing the Environmental Policy

The policy is a statement of goal, vision and commitments of an organization. Employees who have to act on the programs or translate it into action programs and stakeholders who have an interest in the outcome of the programs all need to be aware of the policy statement. Therefore, the policy must be widely communicated by distributing copies to staff members, publishing it in the enterprise's newspaper / magazine, printing it in poster formats, discussing it at meetings, and including it in introduction and at orientation training.

Externally this could be done through Annual Reports, direct mailing and advertisements.

Need for Changes to the Environmental Policy

The policy is not necessarily a fixed document. Formulating a policy could be an iterative process. As the aspects and impacts of an organization's activities, products and services are defined and objectives and targets of activities are set, a refinement of the policy statement may be done in synchronization.

It should be changed as the needs of the organization evolve and as external conditions develop. Some of the situations may necessitate policy changes.

1. Changing legislation and changing expectations and requirements of interested parties,
2. Changes in the products or activities of the organization,
3. Advances in science and availability of technology,
4. Lessons learned from environmental incidents, and
5. The need to address public expectations and concerns

Policy should be adjusted during the overall annual EMS review if necessary. Any changes should be published internally and externally.

Summary

1. The Environmental Management System requires that the organization develop a written policy.
2. The policy should be appropriate to the organization and cover its products, activities, and services.
3. Commitments should be stated clearly on the organization's intent to comply with the law and other internal criteria, the prevention of pollution and continual improvement.
4. The policy should address the issue of care for the environment and public concern attributable to the product, services and activities of the organization.
5. This policy should be communicated effectively internally for understanding and operational reasons as well as externally for the needs of interested parties.

ENVIRONMENTAL ASPECTS (CLAUSE 4.3.1)

The above Element is to be read together with clauses:

ISO 14001 A.3.1 Environmental Aspects
ISO 14004 4.2 Planning

The intent of the element is to ensure a systematic and logical approach to fulfil an organization's Environmental Policy of care for the environment. It is to ensure that an organization's management of the environment is based on sound and scientific knowledge. It corresponds to the required first activity in the Plan, Do, Check and Act cycle of quality management. In this application of PDCA, the organization is to plan how to deal with its environment by identifying how its products, services and activities impact on the environment.

To deal with the task, the organization must first identify the aspects of its products, services and activities. An aspect is anything that is attributable to the organization that could interact with the environment, for example, emission of gases to the atmosphere, addition of extra effluent to the drainage system, discharge of solid and possibly toxic waste that could burden the surrounding ground through pollution of the ground and ground water detracting from proper land use and resulting in odours and aesthetic damage.

The relationship between aspects and impacts is one of cause and effect. The term "aspects" is neutral, environmental aspects could be either positive (such as making a product out of recycled materials) or negative (such as discharge of toxic materials to a stream).

To plan for and control its significant environmental aspects and the consequent impacts, an organization must first know what these are and where they come from. It must know how its waste is generated in order to minimize or eliminate it. The identification and management of environmental aspects can lead to reduction in waste produced or use of fewer raw materials. Both of these will lead to positive impacts on the environment and the profitability of an organization. Generated waste comes from materials that the organization purchased in the first place. Use of less raw materials means more profit.

ISO 14001 requires that an organization shall maintain a procedure on how to identify environmental aspects and significant impacts. The intent is to ensure that the identification process is systematic, logical and repeatable by other personnel who have to accomplish this task.

In its identification process the organization should include a procedure to identify environmental aspects that it can control, and over which it can have an influence. This is of course a reasonable expectation. For example, while an organization probably has control over how much electricity it uses, it likely does not control the way in which the electricity is generated. However its control over consumption could probably reduce waste or use of raw materials by the electricity producer and hence contribute to a better environment.

Once an organization has identified the environmental aspects of not only its products but also its activities and services, it should determine which aspects could have significant impacts on the environment. The identification of the significant environmental impacts is essential as other activities such as formulating or reformulating the environmental policy, establishing objectives and targets, creating an environmental program, control of its operations, etc., are all based on knowledge about the significant environmental aspects of the organization. Controlling these aspects is what an environmental management system is all about. Once it has identified the aspects and impacts, it should keep and up-date this information as the baseline for continual improvements. Also from time to time the organization may want to modify its plants and operations or to embark on another project. This information can then be the basis of change for the future environmental program of the organization.

The control and influence over the environmental aspects of products vary significantly, depending on the market situation of the organization. A contractor or supplier to an organization may have comparatively little control over the outcome of the end product and its use. On the other hand a manufacturer has control over the manufacture of products in terms of the processes used and the selection of materials. The manufacturer could also have some influence over how his product is transported, handled, stored, used and finally disposed.

Identification of Aspects and Significant Impacts

To aid in the identification of aspects ISO 14004 identifies the following as aspects.

1. Emissions to air
2. Releases to water
3. Waste management
4. Contamination of land
5. Use of raw materials and natural resources
6. Other local environmental and community issues

The organization should identify the significant environmental aspects on the basis of these. In identifying the significant aspects of an operation, normal and abnormal operations, shut-down and start-up situations and finally potential emergency conditions must be considered.

Organizations do not have to evaluate each product, component or raw material input. The process is intended to identify significant environmental aspects of the organization and is not intended to require a detailed life cycle assessment.

To begin the identification process, categories of activities, products or services that most likely have a significant impact should be selected. An organization that carries out processing activities could perhaps start with the flow of the process beginning from the intake of raw materials, following through to processing, waste emission and effluent discharges for the processing part and then following further through to storage, transportation, distribution and waste disposal. In parallel, there may be associated activities that go together with the operation of a processing plant. These may include maintenance, transportation, purchasing and storekeeping activities.

There is no standard technique for identifying significant impacts. A multi-step process can be used to make this evaluation. It can start with a simple process for identifying aspects and then the process can be refined over time or the more obvious impacts could be addressed first, the more complex issues being tackled later. However the information derived from this process is to be kept in a register so that it can be updated and used for re-identifying aspects and impacts in the future. This is particularly pertinent when evaluating new products, processes and services and when expanding operations or processes.

Guidelines for Identifying Significance

An aspect is deemed significant of it fulfills the following:

1. If it can result in a direct release of noxious or persistent substances, PCB for example, (In Malaysia these substances are covered by several regulations under the Department of the Environment (Scheduled Waste) or under the Department of Occupational Safety and Health (CIMAH), etc.).
2. If it causes the organization to be out of compliance with regulation.
3. If it contravenes an internal criterion or those of an industry association that the organization subscribes to, for example initiatives such as those of the International Chamber of Commerce, CERES, Responsible Care or STEPS Programs, including an organization's own standards.
4. If it is perceived to be significant by stakeholders (the public or customers), whether it may or may not result in litigation.
5. If it affects business through lowering of image, increase in insurance premiums or loss of insurance validity, lowering of investor confidence in the company, and/or violation its agreements with other parties.
6. If it excessively uses raw materials or resources leading to non-sustainable development.
7. If it generates wastes causing unnecessary loss of revenue through lower profitability on one hand and/or increase in expenditure through costs of clean-up on the other.

Once an organization has found a process for assessing significant impacts that works for it, the process could be written down into a procedure as a part of its Environmental Management System documentation. The aspect and impact process should be carried out by all levels and functions in the organization.

LEGAL AND OTHER REQUIREMENTS (CLAUSE 4.3.2)

The above element is to be read together with Clauses:

ISO 14001 A.3.2 Legal and Other Requirements.
ISO 14004 4.2.3 Legal and Other Requirements.
ISO 14004 4.2.4 Internal Performance Criteria.

The intent of this element is for the organizations to identity legal requirements, international agreements, regulatory and non-regulatory guidelines, codes and industry practices so that it can comply with those that are applicable to the environmental aspects of the organization as necessary. To comply with this is the basis of the environmental policy. It is one of the pillars of an environmental policy statement; others being the prevention of pollution and continual improvement.

A procedure must be set up to track the requirements of this clause. To ensure that at all times the organization has up-to-date information to enable it to comply with legal and other requirements on a continuing basis. To ensure that an organization complies with requirements of this clause, its environmental objectives and targets or other elements of its Environmental Management System are modified as necessary. Tracking the information includes anticipating new legal requirements. The organization can pre-empt a future requirement by modifying its environmental objectives and targets or other elements of its Environmental Management System. These early changes to the organization's operations can enable it to avoid costly changes in the future.

Examples of Regulations

1. Those specific to the activity (e.g. Site-operating permits under Department of Environment, Department of Occupational Safety and Health, etc.)
2. Those specific to the organization's products or services (e.g. transportation)
3. Those specific to the organization's industry (e.g. petroleum products)
4. General environmental laws including international agreements and protocols that are applicable at the location of the organization's activities (Basel Convention, Montreal Protocol)
5. Authorizations, licenses and permits (e.g. licenses under prescribed premises under Department of Environment EQA regulation)

Examples of Other Requirements

1. Company-specific codes of practice (e.g. IT industry)
2. Standards in locations where products are marketed
3. Sustainable development strategies such as Agenda 21, Business Council for Sustainable Development
4. Industry associations codes and initiatives; Responsible Care, STEP, etc.
5. Other industry programs subscribed to by the organization (International Chamber of Commerce, CERES, etc.)

Examples of Internal Performance Criteria

1. Vendor/supplier for supply of chemicals and contractor policy for conduct of services in the organizations' premises
2. Hazardous material, waste, water, air quality and energy management (possibly as an environmental policy sub-statement)
3. Process risk reduction, prevention of pollution and resource conservation

4. Environmental incident response and preparedness
5. Acquisition, management and divestiture of property

Summary

1. Identify applicable laws, rules and regulations, and industry codes of practice and their applicability to the organization.
2. Identify other internal requirements and standards and determine their applicability to the organization.
3. Establish and document a process for keeping both the above up-to-date.
4. Communicate the above requirements to those responsible for the up-date.
5. Communicate the legal and other requirements to all employees.
6. Ensure that the requirements are incorporated in setting objectives and targets and applicable procedures.

OBJECTIVES AND TARGETS (CLAUSE 4.3.3)

The above element is to be read together with Clauses:

ISO 14001 A.3.3 Objectives and Targets
ISO 14004 4.2.5 Environmental Objectives and Targets

The purpose of this element is for organizations to set out clear overall goals (objectives) and specific, measurable ways (targets) for achieving those goals. The objectives must be appropriate and in line with the organization's environmental policy. They should be challenging and yet realistic. In this regard consideration should be given to preventive measures that use the best available technology where it is economical to do so, and opportunities to reduce costs and avoid expenditure keeping in view the financial situation of the organization.

Since objectives and targets should be tailor-made to the organization there are therefore no "standard" environmental objectives that will fit all organizations. Objectives and targets should reflect the aspect and impacts of the organization. Objectives can be set for a specific function to be achieved or for the organization as a whole. Plans could be made to fit the specific requirements of the location of the organization, the resources available, the technology and know-how it can command and obstacles to be faced. Integration with the overall business strategies and other existing in-house management systems of the organization and its environmental and other policies including those for quality and safety is of great importance.

Objectives and Targets Considerations

In formulating the organization's objectives and targets due consideration must be given to the following:

Policy (with regards to prevention, continual improvements)
Legal and other Requirements
Technological and Environmental Aspects (availability of affordable technology)
Operational and Business Requirements (including financial)
Views of Interested Parties (especially customers and affected communities)

The relationship between objectives and targets is as follows:

- Objectives are goals arising from environmental policy, while
- Targets are performance requirements arising from environmental objectives

Targets should be specific with clear definition and scope, detailed and applicable to the whole organization or parts thereof. They should be quantified and measurable where practicable. Finally, there should be a deadline for the achievement of targets.

Objectives can include commitments to

- reduce waste and the depletion of resources,
- reduce or eliminate the release of pollutants into the environment,
- design products to minimize their environmental impact in production, use and disposal and any significant adverse environmental impact of new developments,
- control the environmental impact when exploiting sources of raw material, and
- promote environmental awareness among employees and the community.

Examples of Objectives Setting

1. *Environmental Policy*

   Phase out hazardous substances

   Findings during Initial Environmental Assessment:
   Identified a number of paints in use based on solvents which will be banned in the near future - high/ medium priority

   Suggested objectives/targets:
   Substitute water-based for solvent-based paints in (named process) by (target date)

2. *Environmental Policy*

   Commitment to reduce emission to air

   Findings during Initial Environmental Assessment:
   Identified emissions of ethylene around level allowed in operating license (high priority)

   Suggested objectives/targets
   Reduce annual emissions of ethylene to (target amount) by (target date)

3. *Environmental Policy*

   Commitment to waste reduction through recycling and reuse

   Findings during Initial Environmental Assessment:
   Identified that a large quantity of pallets were being disposed of together with general mixed waste (medium priority- possible savings)

   Suggested Objectives/targets
   Separation and separate disposal of all wood waste by (target date)

When objectives and targets are set, the organization should consider establishing measurable environmental performance indicators. These indicators can be used as the basis for an environmental-performance evaluation system and can provide information on both the environmental management and the operational systems. *(This subject will be discussed further in the section on **Monitoring and Measurements**).*

As in TQM, employees at all levels and functions are to be involved in appropriate activities in the organization. Objectives and targets should be set by the people involved in the respective functional areas. According to the Kaizen principle they are, after all, in the best position to identify problems, establish procedures and achieve goals. Involving people, especially in the early stages of activities, will help build commitment to the overall objectives and targets of the organization.

Summary

1. Document objectives and targets at relevant functions and levels within the organization.
2. Involve relevant functions and levels within the organization in setting objectives and targets.
3. Ensure that objectives and targets are consistent with the environmental policy (including commitments to pollution prevention, continual improvement, and compliance).
4. Ensure consistency with the organization's business plan / mission and other strategies including integration with in-house management systems.
5. Establish a process for tracking and reporting progress.

ENVIRONMENTAL MANAGEMENT PROGRAM(S) (CLAUSE 4.3.4)

The above element is to be read together with Clauses:

ISO 14001 A.3.4 Environmental Management Program(s)
ISO 14004 4.2.6 Environmental Management Program(s)

The intent of this requirement is to ensure that the next logical step is taken to set-up and implement the environmental management system. The environmental management program is the implementation framework for achieving the organization's environmental goals and identified priorities.

The "Environmental Management Program" is a detailed implementation plan, an action plan for environmental objective and its targets and is based on the environmental policy of the organization.

In the process of establishing the program the opportunity must be taken to integrate the requirements of the program itself, that is, the implementation schedules, resources, training and responsibilities for achieving the environmental objectives and targets with the larger strategic business plans of the organization. This should include the integration of existing in-house management systems. The subject of systems integration is not a requirement of the standard but it makes sense in terms of management efficiency and at the same time ensures smooth management of the environmental program itself. As suggested earlier candidates for management system integration are quality, safety and health management systems.

An Environmental Management Program (EMP) in a Nutshell

The EMP is an action plan that sets a schedule of activities, allocates resources such as finance, expertise and staff, and defines their respective responsibilities and training if applicable. It identifies options for achieving targets in terms of technologies to be used, procedures, reporting systems and process changes from existing practice. During the planning activities the opportunity should be taken to identify process and work efficiency improvements.

An EMP is seen as a dynamic plan, which could be modified if necessary. The EMP should be modified along the way if

1. objectives and targets are revised or added,
2. targets are not met,
3. legal framework, products, markets, processes, facilities change, and
4. other factors that cause policy, objectives and targets to change, such as the changes in company or national financial situation, arise.

As mentioned earlier, work on the action plan should be carried out at all levels of the organization whilst targets should be set at all appropriate levels. Not only is this a pointer from ISO 14001 itself but it makes sense from the perspective of quality management since involving staff will ensure effectiveness and commitment.. Senior management should set the priorities as management needs to integrate the plan with other strategic plans. Plans should be integrated into existing organizational structures, for example, health and safety and quality management programs.

Evaluating EMP Options: Considerations

1. Is the solution affordable?
2. Is the option feasible, given staff resources, skills and capabilities?
3. Is there support from other functions such as finance, personnel and marketing?
4. Is the time frame realistic to meet targets?
5. Is the option compatible with the business strategy?
6. Is there proper selection and use of materials and purchasing?

7. Does the program consider product take-back/disposal, energy use, and life cycle analysis?
8. Does it incorporate research and development, design, production and distribution issues?
9. Will it result in short / long-term environmental improvements?

The EMP need not be compiled into a single document. As in the Environmental System Manual *(to be discussed in the **Environmental System Documentation** section)* a document providing a "road map" to several interlinked plans is acceptable.

Implementing Specific Environmental Management Programs

There may be many specific programs that require implementation in an organization at any given time. Each plan must incorporate activities that will ensure control and a means to achieve defined objectives and targets set out for those specific programs. Examples of such programs are as follows:

1. Control of emissions to atmosphere
2. Air Quality Management
3. Emission and effluent inventory
4. Reduction of emission and discharge sources
5. Control of effluent discharges
6. Installation of treatment systems
7. Installation of control equipment
8. Water Quality Management
9. Water use minimization
10. Solid Waste and Hazardous Materials Management
11. Waste inventory
12. Location of waste and hazardous materials storage and disposal areas
13. Risk assessment
14. Procedures to control spill and leaks
15. Waste minimization programs
16. Reduction of materials, reuse, recycling, treatment and final disposal
17. Training and implementation of specific procedures

Summary

1. Prepare an action plan on how the organization will meet its objectives and targets and set deadlines for achievement.
2. Commit resources and include responsibilities.
3. Incorporate environmental concerns in any changes to products, activities, processes, facilities, materials and management processes.
4. Set performance measures and reporting system.
5. Communicate the plan and monitor progress.

STRUCTURE AND RESPONSIBILITY (CLAUSE 4.4.1)

The above element is to be read together with Clauses:

1S0 14001	A .4.1	Structure and Responsibility
1S0 14004	4.3.2	Ensuring Capability
1S0 14004	4.3.2.1	Resources – Human, Physical and Financial
IS0 14004	4.3.2.2	EMS Alignment and Integration
1S0 14004	4.3.2.3	Accountability and Responsibility

This element focuses on the need to define roles, responsibilities, and authorities of everyone involved in the environmental management system. Top management plays a key role by providing the resources essential to the implementation and control of the environmental management system. Resources to be provided include:

1. human resources and specialized skills, and
2. technology and financial resources.

Ensuring this capability and competency is one of the most important jobs of top management.

For an EMS to be effective, roles and responsibilities must be clearly defined and communicated. Any effective management system needs a "champion". Top management should appoint a management representative whose duties are to

1. ensure that the EMS is established and implemented,
2. report on its performance over time, and
3. work with others to modify the EMS when necessary.

The management representative could be the same person who serves as the project champion, but this is not mandatory. Any person can serve as an effective management representative. Just as responsibilities for identifying objectives and targets are delegated to operational managers, the task and general responsibilities for managing the environment should be allocated to individual employees as appropriate.

The task of the environmental representative should be as advisor, co-ordinator, and facilitator to the organization. One underlying principle, however, is that all responsibilities delegated must be supported by the resources, authority and training to accomplish the given task.

The Key to Success – Roles and Responsibilities

Success happens when all employees accept the system by having been involved in the process of building it. Further, employees must know their subsequent roles in the system. They need to know their responsibility, whom they report to, who makes the decisions and how these decisions are made. Examples of roles and responsibilities are as follows:

Top Management (ultimate responsibilities)

- Develop and deliver philosophy and policy
- Monitor performance of the enterprise
- Agree to strategic plan and performance measures

Environmental Coordinator

- Provide advice and keep up to date on legislative and technical issues
- Ensure appropriate methods and procedures are in place
- Verify that monitoring provides objective evidence
- Determine principal causes of problems and non-compliance

Managers

- Implement operational plans, standards, management and control systems, and procedures
- Manage available resources to achieve effective implementation
- Provide timely feedback on performance
- Ensure effective communication of environmental policy and procedures

All Employees

- Follow set procedures
- Provide feedback to managers

Organizational Problems

In the past many organizational systems could not succeed because of the following:

1. Lack of work definition, lack of understanding of work, roles and responsibility duplication or ambiguity of responsibilities
2. Unclear or insufficient authority
3. Insufficient training
4. Insufficient resources including too many responsibilities placed on one individual
5. Lack of authority for the Environmental Coordinator
6. Performance responsibility placed on the Environmental Coordinator instead of top management

Summary

1. Define roles and responsibilities of individuals.
2. Provide resources needed to carry out tasks.
3. Designate a management representative.
4. Communicate everyone's roles internally.
5. Integrate environmental management with other business functions wherever possible and practical.

TRAINING, AWARENESS AND COMPETENCY (CLAUSE 4.4.2)

The above element is to be read together with Clauses:

ISO 14001 A.4.2 Training, Awareness and Competence
ISO 14004 4.3.2.4 Environmental Awareness and Motivation
ISO 14004 4.3.2.5 Knowledge, Skills and Training

The intent here is to ensure that all personnel who may create a significant impact on the environment receive proper, adequate, and appropriate training.

Reasons for Training About EMS

There are two excellent reasons for training about EMS:

1. Every employee can have an impact on the environment
2. Any employee can contribute ideas about how to improve environmental management efforts

It is important that any personnel performing tasks which can cause significant environmental impacts be competent. He or she should have appropriate education and training. However training is just one element of establishing competence. Competence is usually the product of a combination of education, training, and experience. For certain key roles (including tasks which can cause significant environmental impacts), there should be criteria for measuring the competence of individuals performing those tasks.

All personnel should receive awareness training. A special EMS training package should be designed for new employees. Training will not only achieve increased capabilities for an organization but training could help make attitude changes, and changes in behavior patterns and thinking processes in an employee. Job instructions alone is not sufficient to ensure performance. Training for competency is particularly important where an action is to be taken as soon as one sees a potential problem or knows what it is one has to look for.

Training programs are necessary to get the environmental message across, reinforce documentary procedures or instructions and other communication efforts in the organization. Training should start with the most senior management and also include contractors.

Levels of Training

Environmental awareness training should be different at different levels of the organization depending on the responsibilities of personnel, his or her strategic roles in the organization and his or her direct involvement in tasks that can cause high impact on the environment.

Types of Environmental Training

Awareness Training for All Employees

- A basic understanding of global environmental issues and environmental conditions

relevant to the operations of the organization
- An understanding of how their actions may impact on the environmental performance of the organization as a whole

Environmental Policy and Environmental Program Training for All

- Importance of conformance with environmental policy and procedures
- Significant environmental impacts of different activities
- Consequences of departure from operating procedures

Environmental Management Training

- Pollution control and prevention
- Waste management
- Emergency planning
- Environmental management systems and environmental auditing

Professional Training

- Professional qualification requirements of the environmental manager, environmental representative and trainers

Other Environmental Training

- For employees with environmental responsibilities
- For employees whose activities must comply directly with performance and legal standards
- For facility, department and product managers
- For process designers and planners

Key Steps in Developing a Training Program

Step 1: Undertake training need assessment by identifying jobs to be done and the skills required, analyze skills which individuals already have and identify skill gaps.

Step 2: Define objectives of the training (awareness, skills, etc.).

Step 3: Select suitable programs and methods (classroom, workshop, self-study, on-the-job, etc.).

Step 4: Prepare training plan (why, what, when, where, how).

Step 5: Implement program.

Step 6: Monitor and track program and maintain records of training.

Step 7: Evaluate effectiveness of training. In the case of competency training, appropriate evaluation techniques have to be devised.

Step 8: Improve the training program as necessary.

Step 9: Keep training records.

Summary

1. Identify training needs
2. Develop a training plan
3. Provide training at all levels to fulfill the knowledge and competency requirements of the environmental program
4. Monitor and document training
5. Improve training

COMMUNICATIONS (CLAUSE 4.4.3)

The above element is to be read together with clauses:

ISO 14001 A.4.3 Communication

ISO 14004 4.3.3 Support Action

Effective two-way internal communication is crucial in environmental management. It ensures that policies and objectives set by management are understood at all levels of the organization and feed-back on performance, potential problems and suggestions for improvements are properly transmitted to the top. A procedure has to be in place for communication with external interested parties.

Communications will help an organization to explain the organization's environmental policy (both internally and externally) and how it relates to the overall business vision / strategy. It helps motivate the workforce by demonstrating management commitment and ensures an understanding of the roles of employees and expection of management and external interested parties.

Setting up External Communications

There should be a strategy for communicating with the many and varied external interested parties. It is necessary to determine who they are, their interests and concerns and what they need to know about the organization, its products or operations. The organization needs to know what it wants to communicate and how best to reach its designated audiences.

In communicating with employees, it is helpful to explain not only what they need to know and what they need to do but also why they need to do it. For example it is important for them to know why management intends to do certain things which may appear to them to be redundant or superfluous and to explain to them that the action is the requirement of regulation or customers. It is then important for employees to understand their role in the situation or else a situation may arise where the organization as a whole may be out of compliance.

Procedure for Interested Party Communications

As mentioned earlier, interested parties are many and varied. It is helpful to know that they may include Directors of the organizations who may at that the same time be shareholders of the organization, other shareholders, banks or insurance companies who may have more than just a passing interest in the organization and what it is doing. They also include government or environmental authorities who have the public interest to keep, customers who may discriminate against your product, local residents who have their good health and public amenities to protect against possible degrading effects from your operations and environmental groups who have their own varied interests to promote. Finally, the internal interested party are the organization's employees who have the same interests as some of the listed parties mentioned thus far, and in addition they may need to be convinced that they are working for a company that cares for the environment. That environment is where they live!

The communication channels to use for interested parties may include dialogue and consideration of their relevant concerns. Inform them about the environmental impacts associated with the organization's operations through printed or other media. Dialogue with public authorities may be on emergency planning and preparation. Possibly the dialogue may include soliciting their cooperation or involvement with it. Other relevant issues to be raised could be how the organization is trying to meet compliance requirements but is meeting with problems. Identify personnel who shall be responsible for responding to external communications.

Summary

1. Establish procedures for internal and external communication.
2. Determine who is responsible for responding to external inquiries.
3. Identify target audiences.
4. Determine the proper communication method and areas of interest for each audience.

ENVIRONMENTAL MANAGEMENT SYSTEM DOCUMENTATION (CLAUSE 4.4.4)

The above element is to be read together with clauses:

ISO 14001 A.4.4	EMS documentation
ISO 14004 4.3.3.2	EMS documentation

The intent here is that the organization shall establish a manual, either in paper or electronic form that contains key descriptions of how it intends to address all the requirements of the standard and all core elements of the Environmental Management System. In another words, to comment on how it will address the implementation of all seventeen clauses of the ISO 14001 and to provide direction in the manual for finding all the related documents .required to implement the Management System and the records of evidence to show that it is being carried out. The Environmental Management System document is thus a comprehensive source of information of the organization's Environmental Management System. The documentation is therefore a means of communication.

The Environmental Management System documentation gives employees and interested parties a bird's eye view of how an organization's Environmental Management System works.

The EMS documentation being a comprehensive collection of all information required to manage an Environmental Management System supports employee awareness of what is required to achieve the organization's environmental objectives. For interested parties it provides an evidence of the establishment of an organization's Environmental Management System and enables them to evaluate the organization's Environmental Management System and environmental performance.

The Environmental Management System Documentation system serves several other functions, such as a training and reference manual for new employees and relevant committees in the organization that directly or indirectly need to deal with the EMS. It also serves as a base reference document from which changes and audits can be made.

The Environmental Management System Manual does not have to be in the form of a single manual. It may be integrated with other systems such as the quality and safety and occupational health systems. What it has to provide is a guide (or index) for the other documents. The manual does not need to describe every detail of the Environmental Management System. However, there should be sufficient details in the manual to describe

1. the core elements of the EMS,
2. their interaction with other systems, and
3. directions on where to obtain more details.

The Environmental Management System Documents requirement in ISO 14001 is short and terse. In this regard it is similar to the Quality Manual of ISO 9000 which has a similar intent. The manual may be used for stating the organization's commitment. It is used to organize and provide easy access to other Environmental Management System documents. It provides a guide for accessing other manuals and documents such as the manual of procedures, instructions, drawings, reference materials, records and the like.

The content of an EMS Manual should at least have the following:

1. An introduction to the organization, process information, organizational structure and organizational charts, roles and responsibilities, its environmental policy, aspect and impacts, significant aspects, objectives and targets
2. The EMS description, a listed reference to the 1S0 14001 elements
3. Operational procedures and site emergency plans
4. A list of references and a registry of other documents such as regulations and operating permits/licenses, internal standards and initiatives subscribed to, control measures, procedure lists, and an environmental management program

Summary

1. Document the environmental policy, organization, key procedures and other system elements, e.g. procedure for identifying and assessing aspects, impacts and evaluating the significant aspects.

2. Describe how to find documents listed above and related documents, e.g. emergency response plan.

3. Describe the Environmental Management System elements.

DOCUMENT CONTROL (CLAUSE 4.4.5)

The above element is to be read together with clause

ISO 14001 A.4.5 Document Control

The intent of this element is to ensure that all documentation is controlled and distributed. It is meant to ensure that the right people have the correct version of the current documentation and have easy access to them as and when needed at their respective locations. It is also intended that organizations create and maintain documents in such a manner so that it can implement the Environmental Management System effectively.

Employees need the correct and up-to-date tools to do their jobs. Some of these tools include procedures, drawings, charts, work instructions and other documents. To ensure that they are consistently doing the job right, the organization must provide them with the right document. Without a mechanism to control Environmental Management System documents, the organization has no way of knowing or verifying that employees are working with the right tools.

To ensure that everyone is working with the proper Environmental Management System documents, the organization should have a procedure that describes how documents are controlled. Implementation of this procedure should ensure that

1. EMS documents can be located,
2. they are periodically reviewed, and
3. current versions are available where needed and obsolete documents are removed.

Like the Environmental Management System documentation the Environmental Management System document control procedure could emulate the requirements of ISO 9000 Quality Management System Standard closely.

As documents are meant to be used by all employees at all times wherever they work, they should be

1. legible,
2. dated (including revision and effective dates),
3. readily identifiable,
4. maintained in a safe and orderly manner, and
5. retained for a specified period according to internal and legal requirements.

There should be procedures and responsibilities for the creation and modification of the various types of documents. Documents shall include the following elements:

1. Issue/revision date
2. Revision number
3. Effective date
4. Approval (i.e. signature)
5. Document number (or other identifier)
6. Copy number

7. Cross-references
8. Distribution list

Summary

1. Develop a procedure to control EMS documents.
2. Determine the distribution list.
3. Establish responsibilities and authorities for document preparation, revision, management, and disposition.

OPERATIONAL CONTROL (CLAUSE 4.4.6)

The above element is to be read together with clause:

ISO 14004 4.3.3.3 Operational Control

The objective of the Environmental Management System is to ensure that the environmental policy is followed. The environmental policy is based upon prevention of pollution, compliance to laws and regulations and continual improvements. Therefore the organization has to ensure that this intent is preserved through the control of its operations. This is particularly essential if the operation is complex and the impact on the environment is high. To ensure that this happens, certain operations and activities must be tightly controlled. In this instance the control takes the form of documented procedures.

There need not be procedures for everything that the organization does. The decision to have procedures or not depends on the skills and education of existing employees and the complexity and risk of the operation. ISO 14001 stipulates that there should be documented procedures to cover those situations where the absence of procedures could lead to deviations from the environmental policy or objectives and targets. Therefore determining which operations should be covered by documented procedures and how those operations should be controlled is a critical aspect of developing an effective Environmental Management System.

In deciding which activities need to be controlled, an organization should not limit itself to major processes alone. Activities such as maintenance, management of on-site contractors, procurement activities, transportation, materials handling and storage, and waste disposal could affect the organization's environmental performance significantly. These therefore need to be covered by procedures.

Procedures should cover responsibilities for each task, timing and results expected and resources required. The task description should include the selection of technology and materials, design and system operation, delivery of products or services and disposal of wastes. Procedures should cover not only normal operations but also abnormal and emergency situations.

General Causes of Pollution and Its Control Measures

To facilitate writing procedures, it should be noted that the major causes of pollution are, among others, by-product losses, irregular equipment operation, inadequate storage and failure of equipment integrity. Strict procedures aimed at prevention of causes rather than their effects must be adopted to avoid the above. There must be enough pollution mitigating controls where processes are potentially polluting, e.g. when transferring products, handling and transporting material.

Other elements of control include implementation of the following procedures:

1. Management control
2. Employee training and motivation
3. Communication and reporting
4. Preparation and review of procedures
5. Setting performance indicators and standards
6. Performance evaluation

Statistics show that in the field of safety and quality, humans factors are the cause of many deviations and accidents. The following factors should be considered:

1. General health and fitness of employees
2. Stress and fatigue
3. Boredom and complacency
4. Failure to follow procedures
5. Panic in emergencies
6. Conflicts in the work place

Organizations must be aware that there may be weaknesses in their sets of procedures which may cause future problems. These may arise because of incomplete identification of environmental aspects and impacts or poor consultation with employees when drafting procedures, insufficient evaluation of "human factors", instructions which are poorly written or implemented, insufficient or ineffective training, out-dated procedures due to operational changes and incomplete identification of legal requirements.

EMERGENCY PREPAREDNESS AND RESPONSE (CLAUSE 4.4.7)

The above element is to be read together with clause:

ISO 14004 4.3.3.4 Emergency Preparedness and Response

The intent here is that organizations should ensure that there would be an appropriate preparedness and response to mitigate the environmental impact of unexpected incidents. Plans and procedures should be established for this purpose.

The thrust of Emergency Preparedness and Response is to respond to and mitigate environmental damage through accidental occurrences such as emissions to the atmosphere, discharges to water and land, and specific environment and ecosystem effects under abnormal, emergency and unexpected operating conditions and situations. These plans and procedures must be tested periodically. Drills must be undertaken, reviewed and revised after each event and incident.

Some accidents and other emergency situations are beyond the control of the organization such as natural disasters, acts of sabotage, or accidents that are rare such as an airplane dropping out of the sky onto the plant. In preparing for an emergency, consideration of events such as these should also be taken into account.

Preparing the Plan

Before writing the plan, the organization should identify and classify critical processes, abnormal conditions in these processes and likely emergency scenarios and risks related to them whether high or low, big or small. Organize the emergency procedures accordingly. Create an organizational structure and allocate resources and responsibilities.

Identify the necessary equipment required to prevent, mitigate or to remediate the situation, facilities to be made available for refuge or to run temporary operations from, contacts for services or assistance, services required during and after the incident, plans, references, maps, training and finally communication procedures to interested parties and authorities.

After these have been set up, drills and exercises must be conducted. These drills and exercises assist in the identification of weaknesses and thus improvements to the emergency plans can be made accordingly.

Information required to prepare an emergency response plan includes a list of key personnel to be mobilized during the start of the response, communication and reporting requirements, details of emergency services (e.g. fire department, hospitals, transport, supplies, accommodation and spill clean-up services), information on hazardous materials, including each material's potential impact on the environment and measures to be taken in the event of accidental release, and a business recovery procedure.

Summary

1. Review processes and operations for potential emergency situations including scenarios that include situations that are externally induced.
2. Develop plans and procedures for managing these situations with particular emphasis on prevention and mitigation of environmental damage.
3. Train personnel and program frequent drills.
4. Provide or arrange for any necessary emergency equipment.
5. Establish a review mechanism to provide feedback and take into account lessons learnt from experiences during actual incidents or exercises and drills.

MONITORING AND MEASUREMENT (CLAUSE 4.5.1)

The above element is to be read together with clauses:

ISO 14001 A.5.1 Monitoring and Measurement
ISO 14004 4.4 Measuring and Evaluation
ISO 14004 4.4.2 Measuring and Monitoring (ongoing performance)

The intent here is that the key characteristics of the organization's operations and activities be monitored and measured on a regular basis.

The Environmental Management System is meaningless if what is done is not checked to ensure whether it conforms to what is intended and whether the organization has met its objectives. The information acquired from monitoring and measurement could be used not only to compare what is planned with actual performance but could be used to identify root causes of failure and as a basis for continual improvement, which is the foundation of environmental policy.

In order to do this, attention has to be given to what needs to be measured (e.g. those elements that cause significant impacts: e.g. toxic discharge), how to measure it (use flowmeter), by what means (technology) to measure it (turbine/orifice flow meter or chemical analysis in parts per million), to what the measurement should be compared (using indicators, benchmarks, legal requirements) and finally how to derive useful information from data collected (trends, variations, frequency, etc.). The latter is necessary to derive information on how to improve performance and how to find root causes of a problem in order to identify corrective measures.

Measuring and Monitoring

Steps required in monitoring and measurement include analysis of results to identify activities requiring corrective action and improvement, establishing processes to ensure the reliability of data (calibration of instruments, test equipment, and software and hardware sampling), and an ongoing process of identifying environmental performance indicators (indicators should be relevant, objective, verifiable, reproducible, cost-effective, and technologically feasible). An ISO guideline which will be published soon entitled Environmental Performance Evaluation (ISO 14031) will deal with the subject of Environmental Performance Indicators extensively. As a matter of practice, measurement should be made as simple and as clear as possible. Resulting records are to be kept for evidence of regulatory compliance as well as for review purposes.

Some examples of performance indicators are as follows:

1. Fuel utilized per unit of finished product
2. Wastes generated per unit of finished product
3. Waste recycled per unit of material used (for example, the amount of recycled lubricant oil compared to the amount of total lubricant oil used during the same period)
4. Number of complaints in a given period
5. Water consumption per ton of products

For some data and information the analytical tools used extensively in TQM could equally be useful here. These tools include flowcharts, check lists, Ishikawa (fishbone) diagrams, Pareto diagrams, histograms, run charts and control charts.

Summary

1. Identify key process characteristics and the measurement and monitoring of these.
2. Set up a process to regularly evaluate environmental performance (through internal audits) and management review for compliance with laws, regulations and other internal criteria.
3. Determine how to evaluate performance against the set objectives and targets.
4. Establish procedures to maintain and calibrate key monitoring equipment.

NONCONFORMANCE AND CORRECTIVE AND PREVENTIVE ACTION (CLAUSE 4.5.2)

The above element is to be read together with clauses:

ISO 14001	A.5.2	Nonconformance and Corrective and Preventive Action
ISO 14004	4.4.3	Corrective and Preventive Action

Nothing is perfect. Even with good planning and a set of procedures, an organization still sees the need for an emergency response plan to take care of disasters, upsets and unforeseen circumstances. Regardless of the system, deficiencies are always encountered. These could be caused by external changes (regulatory, market, new toxic chemical information) which necessitate different action compared with what was prepared for.

Thus an organization will need to have a procedure to ensure that problems such as the above are investigated. Root causes of operational nonconformances are identified and corrective and/or preventive actions arising out of these are implemented. The corrective actions are documented for subsequent review and for subsequent continual improvement activities. EMS nonconformances and other system deficiencies should be analyzed to detect patterns or trends. Identifying these trends will allow an organization to anticipate and prevent future problems. The quality tools mentioned in Monitoring and Measurements may be used to facilitate this.

It is useful to distinguish the differences between preventive actions and corrective actions. Preventive actions are those actions necessary and generally deemed sufficient to avoid the situation in which a potential problem could become a real problem, whilst corrective actions are those actions necessary to avoid reoccurrence of an encountered problem.

Any corrective or preventive action taken shall be appropriate to the magnitude of problems encountered and commensurate with the environmental impact. One should neither over-do or under-correct. The end must justify the means.

The organization is required to identify who is responsible for handling, investigating, and initiating corrective action and identification of non-conformance. Methods of identification include internal auditing of the organization. Appropriate corrective and preventive action should correct non-conformance in such a way as to be permanent and procedures are set for preventing it from reoccurring, if possible.

Summary

1. Develop procedures for investigating, correcting, and preventing system deficiencies.
2. Assign responsibilities for tracking and completing corrective actions.
3. Set up a review process to revise procedures or other EMS documents based on corrective and preventive actions.

RECORDS (CLAUSE 4.5.3)

The above element is to be read together with clauses:

ISO 14001 A.5.3 Records
ISO 14004 4.4.4 EMS Records and Information Management

Records are kept for three reasons: to provide evidence of performance of an ongoing operation to internal and external parties, such as regulatory authorities; to be used for analysis of performance; and finally as documents for auditing purposes. Good management of environmental information includes a means of identification, collection, indexing, filing, storage, maintenance, retrieval, retention and disposition of pertinent EMS documentation and records.

Organizations must decide what records to keep, how to keep and preserve them, and how long to keep them.

Examples of pertinent records to be kept:

1. Legislative and regulatory requirements e.g. permits, register of applicable regulations
2. Environmental aspects and associated impacts register
3. Training: inspection, calibration and maintenance activity
4. Monitoring data
5. Details of non-conformance: incidents, complaints and follow-up action
6. Environmental audits and management reviews
7. Product identification: materials and property data
8. Services and contractor information for an emergency response plan

Summary

1. Identify records to be maintained.
2. Determine their retention times.

ENVIRONMENTAL MANAGEMENT SYSTEM AUDIT (CLAUSE 4.5.4)

The above element is to be read together with clauses:

ISO 14001 A.5.4 EMS Audit
ISO 14004 4.4.5 Audits of the Environmental Management System

The audit of an Environmental Management System closes the loop in the management system cycle of Plan, Do, Check and Act. Once an Environmental Management System is in place the organization has to verify that the system is followed, is working and has no deficiencies. The audit is meant to provide feedback to management for this purpose and for continual improvement.

For an EMS audit program to be effective the organization should develop a procedure for doing the above. However, this effort is greatly helped as there exist ISO 14010 and ISO 14011 guidelines for this. Nevertheless, the organization still has to undertake certain activities which include the following:

1. Establishing an appropriate audit frequency
2. Training its internal auditors
3. Maintaining audit records
4. Acting on the audit results during management review of the EMS

The results of the EMS audits should be linked forward to the corrective action system and if necessary to the organization's objectives and targets.

What is an Environmental Audit?

An environmental audit is used to assess how well the EMS is functioning. It is a management tool for evaluating how well the environmental organization, management and equipment are performing to safeguard the environment.

Summary

1. Develop an audit program.
2. Determine an appropriate audit frequency.
3. Select and train EMS auditors.
4. Conduct EMS audits as described in the program.
5. Keep records of these audits.

MANAGEMENT REVIEW (CLAUSE 4.6)

The above element is to be read together with clauses:

ISO 14001 A.6 Management Review
ISO 14004 4.5.2 Review of the Environmental Management System
ISO 14004 4.5.3 Continual Improvement

An organization should review and continually improve its environmental management system, to ensure its continuing suitability in the face of changing circumstances, its adequacy to cope with new situations and evaluation of its performance and its ongoing effectiveness in meeting policy objectives.

There are three reasons why a Management Review is necessary. Firstly, there might be weaknesses in the system that were not foreseen until the system operated. Secondly, there is the requirement that the organization should always take an opportunity to improve the system to lead to greater efficiencies and thus profitability for the organization. Lastly, when the organization first set its objectives and targets and embarked on its environmental programs, it may not have had the ability or opportunity to create an environmental improvement program that it would have wished to make. This may be on the account of financial and other resource constraints including know-how and availability of viable technology. The review can then serve as the stepping stone to continual improvements.

Among the people involved in the management review process should be those who can make decisions. Whilst the environmental representative plays the key coordinating role, those who are responsible for environment performance should also be involved.

Among other things to be discussed during the management review are the possible need for changes to the environmental policy, objectives, targets and other elements of the Environmental Management System. The sources of insight to these changes are the results of Environmental Management System audit and changing circumstances like changes in market requirements, changes in laws and regulations and changes in products, materials or processes, just to name a few.

Other items to be discussed at the review could include the following:

1. Impact on financial performance and market competitiveness
2. Evaluation of the Environmental Management System effectiveness
3. Expectations and requirements of interested parties
4. Advances in science and technology
5. Lessons learned from environmental incidents

The Management Review should demonstrate that it is management's commitment to continual improvement which is the driving factor in this process. It should also demonstrate management involment in environmental management.

Whilst the review process should identify the overall opportunities for improvement, the improvements to be considered need not take place in all areas of activity.

Key among other issues to be discussed are those in the areas of corrective and preventive action and the question of how the organization is to verify that corrective and preventive actions and improvements are effective and timely.

There is also the requirement for documenting the management review, the plan for review and the Management Review itself. The requirement of the review is similar to both ISO 14001 and ISO 9001. However in ISO 14001, there is the additional requirement to review the environmental policy, objectives, and targets.

Summary

1. Establish a process for periodic reviews of the organization's EMS.
2. Document the results of such reviews.
3. Follow-up on decisions taken at the Review.

ENVIRONMENTAL MANAGEMENT SYSTEM STEPS IN IMPLEMENTATION

Getting Started

The steps in getting started are straightforward although the essential thing is to get the support from top management.

In general the initial activities are as follows:

- Start working on the identification of significant environmental aspects.
- Incorporate the organization's history to understand how previous operations can affect current operations and future liability.
- Identify interested parties requirements, laws and regulations and requirements of ISO 14001.
- Formulate an environmental policy.
- Prioritize the significant aspects.
- Set objective and targets.
- Work on the environmental program, assess the strengths and weaknesses, benefits and costs of the program.
- Identify in-house capability and what training need to be undertaken.
- Evaluate benefits and costs of status quo i.e. business as usual.
- Evaluate programs procedures already existing in-house, see what could be integrated and what needs to be done to close the gap for implementing an ISO 14001 Environmental Management System.

Presenting Your Arguments to Management

Management must be convinced of the benefit of any program before it can be accepted. Thus, presentation of arguments needs to be based on business strategy and goals, on the interests of health, safety and the environment, and finally on how it will benefit workers and hence the management.

Strategies for Implementing an Environmental Management System

An organization does not always have to implement the ISO 14001 Environmental Management System by starting with implementing clause 4.1 and going on to 4.6 of the Environmental Management System step-by-step. Although the clauses are arranged in a Plan, Do, Check and Act layout, the actual implementation depends very much on what is happening within the organization. Normally, one will have to identify the significant aspects of the organization first in order to formulate the environmental policy and then the environmental Objectives and Targets.

The strategy may depend on whether

1. the organization has some environmental management system in place,
2. the organization has existing environmental programs, but these are individual programs addressing the environment issue by issue, or
3. the organization is initiating a system from scratch.

If the Organization has Established some Environmental Programs

Evaluate the compliance of the organization's program to applicable legislation/regulation and other requirements. Correct any shortcomings with respect to the ISO EMS. Carry out an audit and bridge the remaining gaps. Review the resulting system and include improvements where possible.

If the Organization has an Existing System

Bridge all the gaps between an existing system and ISO 14001 requirements. Begin with from the largest gap.

If the Organization has No System

Set up a procedure to evaluate environmental aspects as per Section 4.3.1. of ISO 14001. Set up and implement a procedure to identify legal and other requirements as per Section 4.3.2. Identify the Objectives and Targets, and then develop the Environmental Management Program, etc. Simultaneously, formulate the Environmental Policy and follow the rest of the standard to completion. In implementing the program, take care of awareness and competence training and training of would-be internal auditors.

FURTHER READING

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6 BRIDGING THE GAP BETWEEN ISO 14001 EMS AND ITS APPLICATIONS IN CERTIFICATION OF FOREST MANAGEMENT

WAN RAZALI WAN MOHD.

Eco-labeling of manufactured goods began a few decades ago and its implementation has been mainly at the national levels. A variety of logos has been used. Some examples are exhibited in Figure 1.

Countries such as Denmark, Germany, France, Italy, United Kingdom, Canada, Japan, and last but not least the United States of America are leading multistate committees that have established the criteria for the various product categories. The headlines of various articles exemplified the importance of product eco-labeling in this era of environmental consciousness by the public at large (Boxes 1, 2, and 3).

Household products (e.g. washing machines, dishwashers and refrigerators), kitchen towels, washing detergents, paints and varnishes, batteries, copying and writing papers, toilet tissues, insulation materials, building materials, and other paper and wood products have been included in many of such eco-labeling schemes but the environmental assessment has been typically limited to the production process. Only recently has attention turned to raw material supply as part of a product's life cycle.

OBJECTIVES OF THE CHAPTER

Given the above scenario, the framework of ISO 14001 (Figure 2) and the non-sector (or commodity) specific Environmental Management System (EMS) standards, it is the objective of this paper to provide some insights to certification of forest management under ISO 14001 using a general performance standards. These performance standards usually encompass forestry policy matters and/or regulatory framework, biological or ecological, environmental, economic, and social factors. Furthermore, for an organization to have its EMS certified it is required to choose its own set of forest management performance standards. The non-availability of a general guideline for a forest organization and forestry professional to audit or certify environmental requirements of forest management practices in the tropics make it all the more important to bridge the gap between ISO 14001 EMS and its applications in certification of forest management.

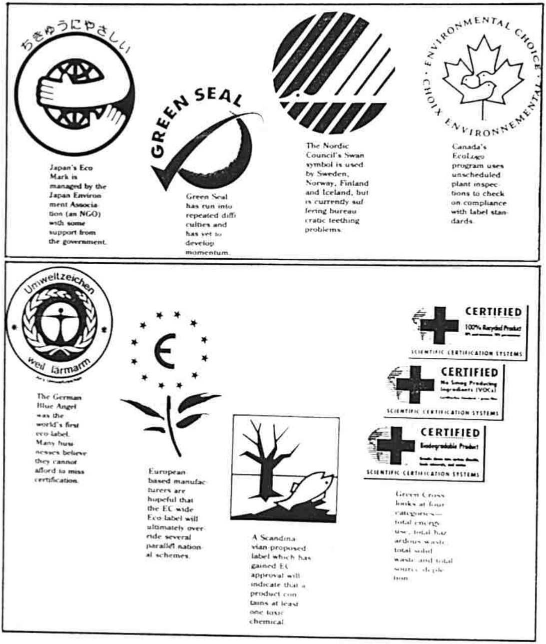


Figure 1: A Variety of Logos
(Source: TOMORROW, 1993)

An Eco-Label is

COMING YOUR WAY

(Source: TOMORROW, 1993)

BOX 1

UNITED COLORS

of Eco-Labeling
Green labels as a sales gimmick are history but the concept itself is showing distinct signs of life.

(Source: TOMORROW, 1993)

BOX 2

Eco-label the carrot,

LEGISLATION THE STICK

(Source: TOMORROW, 1993)

BOX 3

UNDERSTANDING SUSTAINABLE FOREST MANAGEMENT : BASIC DEFINITION

While it is necessary to have a working understanding of the term "**Sustainable Forest Management (SFM)**", it will be futile to develop an agreed definition as a pre-requisite to further consideration of standards.

Therefore, there are many definitions of **Sustainable Forest Management and Sustainable Forestry** (Boxes 4, 5, 6).

UNCED Statement of Forest Principles

Forest resources and forest lands should be sustainably managed to meet the social, economic, ecological, cultural and spiritual human needs of present and future generations.

BOX 4

ITTO Sustainable Forestry Management

Sustainable forest management is the process of managing permanent forest land to achieve one or more clearly specified objectives of management with regard to the production of a continuous flow of desired forest products and services without undue reduction of its inherent values and future productivity and without undesirable effects on the physical and social environment.

BOX 5

Canadian: What is SFM?

The maintenance and enhancement of the long term health of forest ecosystems, for the benefit of all living things while providing environmental, economic, social and cultural opportunities for the benefit of present and future generations.

BOX 6

SUSTAINABLE FOREST MANAGEMENT: THE ISSUES

Recent years have seen progress towards multi-lateral agreements between nations on environmental issues and the sustainable management of natural resources. During this time forestry has been a focal point on the international agenda. Concerns on the environment have given a new focus on the role of forests, especially tropical forests. Sustainable forest management is becoming the maxim by which all forests will be managed presently and in the future.

The issue of SFM came into sharp focus during the Earth Summit (Rio de Janeiro, July 1992) when the "Forest Principles"[1] were agreed upon by more than 170 countries. Since then, various inter-governmental, national and regional initiatives have been undertaken to implement "Agenda 21"[2] adopted at the Earth Summit. As a result, sustainable forest management has emerged as a major global issue. It is gaining momentum to the extent of threats and demands on consumers to purchase only timber and/or timber products produced from "sustainably managed forests". This has lead to the development of certification of forest management.

CERTIFICATION OF FOREST MANAGEMENT

The interest in certification of forest management and subsequent labeling of forest products is relatively new. Begun in the early 1990s mainly as a result of lengthy campaigns by international environmental agencies and NGOs to conserve tropical forests, certification of forest management has developed alongside a growing trend for eco-labeling of consumer products. It is linked to producers and/or manufacturers of timber and timber products who are seeking to improve their forest management practices, obtain better market access, and inform and educate their consumers of environmental benefits of good quality forest management.

Definition

Forest certification can be defined as a process which results in a written certificate of approval attesting to the management status of the forest as fulfilling all requirements of a set of performance standards from which the timber originated. That process, and hence the issuance of the certificate, is usually carried out by an independent third-party.

There are normally two components in forest certification:

Forest Management Certification
Also refers to **Forest Auditing**. This involves inspection of forest management practices on the ground against a specified set of performance standards towards achieving a status of,

[1] The full title is "Non-Legally Binding Authoritative Statement of Principles for a Global Consensus on the Management, Conservation and Sustainable Development of all Types of Forests."

[2] An action plan that elaborates strategies and program measures to halt and reverse the effect of environmental degradation and to promote environmentally sound and sustainable development in all countries. Chapter 11 (Combating Deforestation) and Chapter 15 (Conservation of Biological Diversity) deal with forestry matter, among others, leading to the needs of sustainable forest management.

for example, well-managed forest, quality managed forest, or sustainable managed forest. The standards usually encompass policy matters and biological or ecological, social, economic, and environment factors. It serves to answer the question **"Is a particular forest being managed on a sustainable basis?"** Certification can potentially be carried out at different levels - national level or forest management unit level. Existing certification programs work best on and are also most reliable at the forest management unit, from which upward progress can be made.

Forest Product Certification
This is a tracking system used in order to ensure that the timber concerned actually originated from a forest whose management has been certified. The timber product is monitored from its certified source to the consumers. The monitoring process is also referred to as the **"Chain-of-custody"**, which involves log transport and processing, shipping, and further processing until it reaches a customer. A label is usually attached to a forest product that has complied with all requirements of the chain-of-custody.

Operational Characteristics of an Effective Certification Scheme

Markets will only recognize labels if the assessing and/or certifying agency and the labeling scheme itself are reliable, transparent and credible. To be internationally acceptable a forest certification system must be voluntary, more so if timber and timber products are exported. Therefore, a certification scheme in forestry should have the following characteristics (Box 7):

1. **Acceptable to and implementable by national governments and forest owners**
2. **Acceptable to customers in both domestic and international markets**
3. **Reliable, transparent, and independent in its procedure of assessment or audit**
4. **Practical to implement, based on some agreed performance standards[1] that are understood at all levels of the timber and wood market chain**
5. **Appreciative of commitments to improvement and progress towards practical achievement of sustainable forest management within a time frame agreed to by international community**
6. **Not used as a non-tariff barrier against producer countries**
7. **Applicable to all types of forests**
8. **Cost effective especially to small-scale forest owners or operators**

BOX 7

One pertinent question to ask is, **"Can such a certification scheme be developed?"**

[1] In forest management certification, the performance standards are usually referred to as a set of principles, criteria and indicators

STANDARDS IN CERTIFICATION OF FOREST MANAGEMENT

Two types of standards are available in certification of forest management, namely **Performance standards** and **Procedural standards** (Simula, 1996). Procedural standards are sometime referred to as **Management System standards** (Standard New Zealand, 1995).

Performance standards are basically a set of principles, criteria, and indicators in the certification of forest management, against which forest management practices on the ground are assessed as either fulfilling the standards or otherwise before a written certificate can be awarded. Some examples of organizations or processes having such standards are categorized as in Box 8.

EXAMPLES OF ORGANIZATIONS OR PROCESSES HAVING STANDARDS IN FOREST MANAGEMENT CERTIFICATION

Intergovernmental: The Helsinki Process [4] ; The Montreal Process [5]; ITTO[6]; Tarapoto [7] ; ATO [8]

Non-Governmental Organizations (NGOs): SGS-Forestry (UK): QUALIFOR Program; Rainforest Alliance (US): Smart Wood Program; The Soil Association (UK): Wood Mark Program; SCS (US): Forest Conservation Program; WWF: Criteria for Forest Quality.

National[9] : CERFLOR (Brazil); Initiative Tropenwald (Germany); LEI (Indonesia); Forestry Accord (New Zealand); Living Forest Program (Norway); Richer Forest Program (Sweden); MC&I (Malaysia)

BOX 8

On the other hand **Procedural (or Management System)** standards in forestry have been generally accepted to be the ISO 14000. The framework of standards is given in Box 9.

[4] European criteria and indicators for the conservation and sustainable management of temperate and boreal forests.

[5] Non-European criteria and indicators for the conservation and sustainable management of temperate and boreal forests.

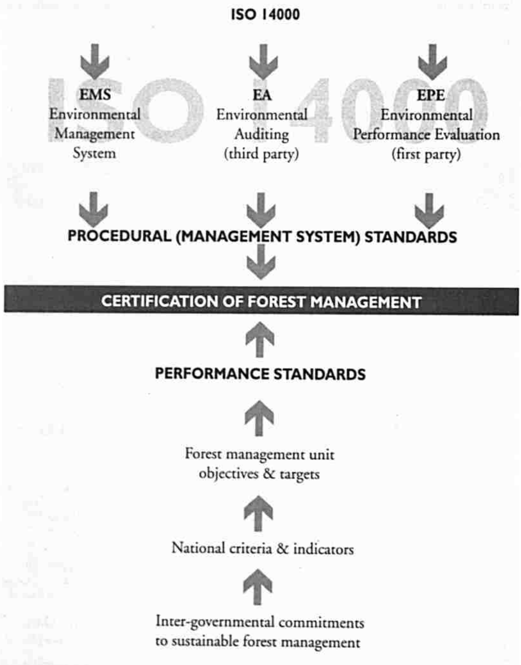
[6] International Tropical Timber Organization: criteria and indicators to meeting ITTO Objective Year 2000 in achieving sustainable management of tropical forests and trade in tropical timber from sustainably managed resources by the year 2000.

[7] Criteria and indicators for sustainability of Amazon forests (8 Amazonian basin states).

[8] African Timber Organization: a forum for the development of forest management and trade policies for its 13 member nations.

[9] ISO/TC 207/WG2 Forestry N82: Technical Report-Draft 04, July 1997

FRAMEWORK OF PROCEDURAL AND PERFORMANCE STANDARDS IN CERTIFICATION OF FOREST MANAGEMENT



(Source: Modified after Simula, 1996 & Standards New Zealand, 1995)

BOX 9

ISO 14001: ENVIRONMENTAL MANAGEMENT SYSTEM-SPECIFICATION WITH GUIDANCE FOR USE

This International Standard has been approved by ISO/TC207[10] and published in 1996. Other related ISO Standards (14000 series) that have been published include guidance on various environmental issues, such as:

1. **ISO 14004: Environmental management system - General guidelines on principle, system and supporting techniques**
2. **ISO 14010: Guidelines for environmental auditing - General principles**
3. **ISO 14011: Guidelines for environmental auditing - Audit procedures - Auditing of environmental management systems**
4. **ISO 14012: Guidelines for environmental auditing - Qualification criteria for environmental auditors**
5. **ISO 14040: Life cycle assessment - Principles and framework**

Other related standards under development include:

6. **ISO/DIS 14020 - Environmental labels and declarations - General principles**
7. **ISO/CD 14031 - Environmental performance evaluation**

ISO 14001 does not prescribe environmental performance criteria. It requires an organization to develop its own policies, objectives and targets. An organization can have its Environmental Management Systems (EMS) certified against ISO 14001. Thus certification implies that an organization has an EMS in place and is operating to meet its policy, commitments, objectives and targets.

An environmental management system is a framework designed to provide effective direction for an organization's activities insofar as they affect the environment. The components of the ISO 14001 framework are shown in Figure 2.

ISO 14001 VERSUS SUSTAINABLE FOREST MANAGEMENT

Sustainable Forest Management (SFM) emphasizing environmental aspects will require organizations to have and implement EMS. Organizations then can have their EMS certified against ISO 14001.

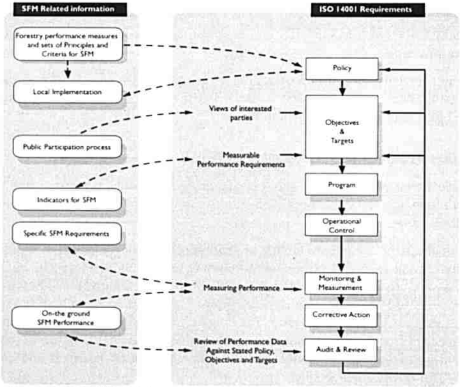
Internationally, some commercial forestry organizations have taken many varying initiatives. Others have promoted and implemented various programs aimed at advancing the concept of SFM. As a result, a variety of standards and certification procedures for SFM have been/are being developed which have a high potential for contradictory claims leading to market confusion and possible barriers to trade. The international commercial forestry community is eager to establish appropriate standards and believe that any certification must be voluntary. Thus, the use of ISO 14001 could provide an internationally accepted and coherent framework for certification of SFM.

[10] TC 207 is the technical committee that standardizes environmental management. Its terms of reference preclude it from setting performance levels.

Figure 3 illustrates the possible links between the management system approach of ISO 14001 and performance standards approach using principles, criteria and indicators of sustainable forest management.

(Source: ISO/TC 207/WG2, 1997)

Figure 2: ISO 14001 Framework



(Source: ISO/TC 207/WG2, 1997)

Figure 3: Application of Principles, Criteria and Indicators for Sustainable Forest Management in the Framework of ISO 14001

ORIGIN, MEMBERSHIP AND MEETINGS OF THE ISO/TC207/WG2: FORESTRY FOR CERTIFICATION OF FOREST MANAGEMENT

At the ISO/TC 207 plenary meeting in Oslo from 24 June - 1 July 1995, a New Work Item on **"Guidance to the application of ISO 14001 for Sustainable Forest Management"**, jointly proposed by Canada and Australia, was withdrawn for further consideration. The meeting firmly resolved that ISO 14001 should be advocated as the single world-wide EMS standard and that consideration of any sector specific standards should be deferred until the next revision of ISO 14001 (Resolution 18/1995). The basis of this decision was the concern that sector specific standards would undermine the integrity of the generic ISO 14001 standard.

Many TC207 members recognized that the issue of the ISO 14000 series and certification of forest management with a view to promote SFM needed further consideration. **The Informal Study Group** was proposed by New Zealand and supported by other TC207 members with the expectation of reporting back to the TC207 plenary meeting in 1996 (Rio de Janeiro, Brazil).

The Informal Study Group reported back to TC 207 with the conclusion that ISO 14001 is a suitable international framework for promoting sustainable forest management, provided that it is linked with a **"bridging document"**. This bridging document states that an organization may chose its own set of performance standards from among the existing ones, using EMS as a framework in forest certification. The Study Group believes that ISO recognition of a bridging document would improve acceptance and credibility.

The other recommendation of ISO/TC 207 (Resolution 11/1996) was for the establishment of a formal **Working Group (ISO/TC 207/WG 2 FORESTRY)** to prepare a technical report describing **Informative Reference Material to Assist Forestry Organization in the Use of ISO 14001 and ISO 14004 EMS Standards**[11] (referred to as the "bridging document" earlier).

The above technical report was finalized and presented at the 6th ISO/TC 207 meeting held in the United States in 1998. The scope of the report has to be consistent with the ISO/TC 207 Resolution 11/1996 (Wan Razali and Zul Mukhstar, 1997[12]):

ISO/TC 207 Resolution 11/1996 states that the report must

1. **be within the scope of TC 207 Terms of Reference,**
2. **be consistent with the Resolution 18 of ISO/TC 207, 1995 and the ISO/TMB Resolution 3/1996 regarding sector specific ISO EMS standards,**
3. **not specify performance levels for forestry and therefore the report in itself, cannot form the basis for performance claims, and**
4. **not create a product label.**

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[11] This technical report, as of October 1997, is available as document ISO/TC 207/WG2 on Forestry N82 (Draft 04) after the Draft 03 was presented at the 5th Meeting of ISO/TC 207 in Kyoto, Japan from 18 - 25 April, 1997.

[12] Report of the third meeting of ISO/TC 207/WG2 - Forestry, April 18-25, 1977 (concurrent with 5th meeting of ISO/TC 207 Environmental Managements)

SCOPE OF THE REPORT: INFORMATIVE REFERENCE MATERIAL TO ASSIST FORESTRY ORGANIZATIONS IN THE USE OF ISO 14001 AND ISO 14004 EMS STANDARDS

The scope of the above technical report as stated in the above report is as follows:

> "This technical report should be used in conjunction with ISO 14001 and 14004. It provides a bridge between the management system approach of ISO 14001 and the range of forest policy and forest management performance objectives, including SFM Criteria and Indicators that a forestry organization may wish to consider. It also provides reference to the ISO 14000 series of standards, application of forestry laws and regulations, and the other matters that a forestry organization may want to take into consideration as it implements an environmental management system.
>
> This technical report does not add any additional requirements to ISO 14001, nor does it establish performance levels for forest management."

ENVIRONMENTAL MANAGEMENT SYSTEM REQUIREMENTS IN THE CERTIFICATION PROCESS: BRIDGING THE GAP BETWEEN ISO 14001 STANDARDS AND FOREST MANAGEMENT STANDARDS

Objective of Assessment of Forest Management

The objectives of assessment of forest management in certification are as follows:

1. To ensure that the management team of a forestry organization has a clear understanding of the certification process, the necessary long-term commitments to their EMS, and the measures that need to be taken to make their EMS certifiable against ISO 14001.
2. To examine the status of an organization's EMS in relation to its forestry practices, including the adequacy of the organization's environmental performance criteria (policy, objective, and target) as judged from a relevant set of principles, criteria, and indicators (if any).
3. To identify and report areas of an organization's EMS that require improvements to forest management practices that would prevent the organization from being certified against ISO 14001. The means by which the required improvements are made and the time it takes are entirely the decision of the organization.

It must be remembered that every effort should be made to ensure that the certification assessment or audit is comprehensive, reliable, and transparent and representative samples, because of large coverage of forest areas, are assessed.

The following illustrates examples of forest management activities that would be needed for an organization to be ISO 14001 certified. The activities given are not exhaustive and depend on which operating unit (or forestry activity, e.g. forest harvesting, plantation establishment, etc.) needs to be assessed and certified.

Environmental Policy (ISO Clause 4.2)

ISO 14001 requires that an organization's environmental policy be documented, implemented and maintained, and made available to all employees and also to the public. It must include commitments to comply with relevant environmental legislation and regulations and other requirements to which the organization subscribes, as well as to continual improvement and prevention of pollution.

This policy provides a framework for action and for setting an organization's environmental objectives and targets. The environmental policy needs to recognize and address all activities, products and services that can have an impact on the environment.

Last, but not least, the **Environmental Management System Organization Chart** should be available at all times.

In short, it is the organization's Clients Charter in relation to its EMS. An example of environmental policy of a forestry organization could include the following (as an illustration only; applicable to Malaysia):

OUR ENVIRONMENTAL POLICY

We, the employees of XYZ, have been entrusted with the management and development of these natural resources. We are responsible to ensure that our objectives, activities, products and services conform to the environment through the following:

- We will manage all forest resources (timber and non-timber) within the Production Forests on a sustained yield basis for biological, economic, environmental, and social purposes, subject to yearly review in accordance with legal and applicable laws and regulations.
- We will comply with ITTO criteria for the measurement of sustainable tropical forest management; ITTO guidelines for the sustainable management of natural tropical forests; ITTO guidelines on the conservation of biological diversity in tropical production forests; and ITTO guidelines for the establishment and sustainable management of planted tropical forests.
- We will comply with all applicable legal requirements of National Forestry (Amendment) Act 1993 in managing our resources sustainably.
- We will comply with all applicable legal requirements of Environmental Quality (Prescribed Activities) (Environmental Impact Assessment) Order of 1987 of Environmental Quality Act 1974.
- We will comply with all applicable legal requirements of Aboriginal Peoples Act 1960.
- We will comply with all applicable legal requirements of Land Conservation Act 1960 and National Land Code 1965.
- We will undertake to practice a policy of "no burning" in all aspects of our forestry resource management.
- We will monitor and continually improve our environmental performance.
- We will undertake to increase environmental awareness of our employees through continuous education and publicity.
- We will re-evaluate and act accordingly on our Environmental Policy, including its objectives and targets based on the results of Environmental Impact Assessment.

Planning (ISO Clause 4.3)

A forestry organization must consider planning aspects affecting the environment, for example in the preparation of a long term forest management plan, an annual harvesting plan, a reforestation plan, an harvesting and transportation plan, etc., some details of which are given below.

Environmental Aspects (ISO Clause 4.3.1)

A forestry organization needs to identify its activities, products and services that it can control and which can have significant impacts on the environment. Some examples or issues to consider are:

Forest management for timber production causes erosion, sedimentation, soil compaction, bio-diversity change, and wildlife disturbance. Therefore appropriate activities should be identified during planning in order to mitigate its environmental impacts, *vis a vis:*

1. *Reduction of erosion, accelerated run-off and sedimentation through*

    i. zoning of forest by its function (for example: production, protection, community needs, recreation, etc.),
    ii. encouraging low impact harvesting methods,
    iii. harvesting and carrying out forest road construction during dry season only,
    iv. no ground skidding across stream,
    v. appropriate use of harvesting machinery during harvesting and road construction
    vi. no blading of top soil,
    vii. instituting correct road density (both main road, haul road and skid trail), and
    viii. implementing a road gradient, width and drainage system in accordance with minimum requirement.

2. *Reduction of fire hazards through*

    i. implementing a fire management plan for plantation forests based on prevention, detection and suppression.

3. *Prevention of soil, underground water, stream and river contamination by*

    i. never using chemicals (herbicides and insecticides) that have been banned and
    ii. using only biodegradable chemicals.

4. *Safeguarding water quality and reduction of water turbidity by*

    i. forest zoning according to site suitability, especially in establishment of industrial tree plantations,
    ii. no blading of top soil,
    iii. prescribed burning in forest tree plantation, if required, and
    iv. allocation of adequate width of bufferzone around the river or stream during harvesting.

5. *Protecting community health through*
   i. prevention of fire occurrence by awareness campaigns, and
   ii. avoidance of use of chemical pesticides identified by WHO as Type 1A and 1B and hydrocarbon pesticides.

A forestry organization may also develop criteria to evaluate the significance of environmental impacts related to its environmental aspects. General information is provided in Section 4.2.2 of ISO 14004 and hence will not be elaborated here.

A typical method to evaluate significance of impacts in Malaysia is through the use of **Techniques or Methods of Rapid Assessment** as found in **EIA GUIDELINES FOR TIMBER HARVESTING IN NATURAL FORESTS** (FRIM 1997)[13]. Elsewhere, the use of **Significance Index** was proposed (ISO/TC 207/WG2, 1997).

Legal and Other Requirements (ISO Clause 4.3.2)

ISO 14001 requires that an organization shall establish and maintain a procedure to identify and have access to legal and other requirements. A good procedure is for a forestry organization to develop, maintain and update and make available copies of all documents - legal or otherwise - to which the organization subscribes its environmental aspects.

For example, an organization has been approved by the Government to establish an industrial forest plantation but it dictates that there are other land use requirements inside such a forest plantation that will affect its environment. Furthermore, a requirement is also imposed on that organization such that a maximum of 5% of the area is allowed to be covered by buildings and other infrastructure (roads, fire towers, open spaces, etc.). What are then some of the ISO 14001 requirements?

1. A logical step is for the organization to keep record evidence and/or *in-situ* evidence that various land use and stipulated size of the area occupied by the infrastructure requirements are being fulfilled.
2. The organization should ensure that forest management planning is based on comprehensive species-site matching and takes account of appropriate site or environmental constraints and silviculture prescriptions, especially when dealing with the chemicals.

Examples of forestry related laws in Malaysia, guidelines, policies, and code of forest practices (example: FAO Model Code of Forest Harvesting Practice) were given in the section on **Environmental Policy**.

Environmental Objectives and Targets (ISO Clause 4.3.3)

ISO 14001 requires a forestry organization to establish and maintain environmental objectives and targets that are consistent with its environmental policy. Environmental objectives should be specific and targets measurable.

[13] *FRIM Technical Information Handbook* No. 14.1997. A Technical Committee, Ministry of Primary Industries Malaysia, and Department of Environment, Malaysia, have approved it.

In certification of forest management, environmental objectives and targets could be referred to as performance standards, mostly consisting of criteria and indicators for the measurement of sustainable forest management. These performance standards can be based on the existing international or intergovernmental or national criteria and indicators, but they can also be developed by an organization as long as the standards follow acceptable codes of forest practices and are internationally and professionally recognized.

A specific Malaysian example of a forestry organization's **environmental policy** of minimizing soil erosion from forest road construction prior to and after logging are based on guidelines **"Specification for logging road construction in Peninsular Malaysia 1988"[14] , "Guidelines for logging in Hill Forest Peninsular Malaysia 1988"[15] , "Guidelines for Forest Harvesting 1984 "[16] and "Criteria, indicators and activities for sustainable forest management, Malaysia 1995"[17]** or other similar guidelines that the organization has prescribed to. Therefore, the approach taken by this organization involves the following:

1. *Environmental objectives:* To implement and control a forest management plan effectively with respect to minimizing soil erosion.
2. *Environmental targets:* To lay out forest roads and skid trails prior to logging in accordance with the standards in the forest management plan. Forest roads and skid trails are measurable in terms of number and area. For example, under the standards, main road is 10-12 meter in width, branch road, 8-9 meter and skid trail, 4-5 meter; maximum allowable grades are 10%, 15% and 30% respectively for a main road, branch road and skid trail. The end results would be fewer gullies on the road, and reduced suspended solid and turbidity in the stream and river.

Another example is the organization's environmental policy of protecting ground water for human consumption from contamination with chemicals and oil. The organization may receive complaints that underground water and water from the stream are not fit for human consumption because of high acid content. The following approach could be taken:

1. *Environmental objectives:* To dispose of used engine oil from all vehicles belonging to the organization in an environmentally safe manner and to prevent chemicals used in the forest nursery from entering the stream or river system.
2. *Environmental targets:* The organization has identified the acidity level in the water supplied to all houses in its timber or plantation complex as a measurable indicator of water pollution. As such the organization has improvised a proper method of disposing of the used engine oil by sending it to the treatment plant and by practicing high hygiene and nursery management standards such that any chemical used in the nursery will not leak into the nearby stream and river.

[14] This specification is available from Forestry Department Headquarters, Peninsular Malaysia.
[15] See footnote 14.
[16] See footnote 14.
[17] See footnote 14.

Environmental Management Program (ISO Clause 4.3.4)

A management program must address the organization's environmental objectives and targets. It must designate an authority to achieve those objectives and targets within a specific time frame.

Following the above example on soil erosion, the Timber Harvesting (Logging) Department of the organization is entrusted to carry out the responsibility immediately after each phase of operation. Therefore, the unit has to develop, for example, the following environmental management programs:

1. Roads, where possible, are located on ridges and uphill skidding is practised.
2. Logging is carried out only during dry season only.
3. Logging on areas beyond 30 degrees slope (if necessary) is only by aerial methods, e.g. Skyline.
4. After logging, waterbars or cross-drains are constructed across the road and skid trail at a distance of between 20m to 30m so that water flow is reduced in terms of volume and speed and hence soil erosion minimized.
5. Roads are maintained by the maintenance crew at regular intervals using established schedules and procedures.

Similarly, as in the above example on used engine oil and chemicals in the nursery, the following programs need to be instituted by the Heavy Equipment (Vehicle) Department and the Forest Planning & Management (Nursery) Department:

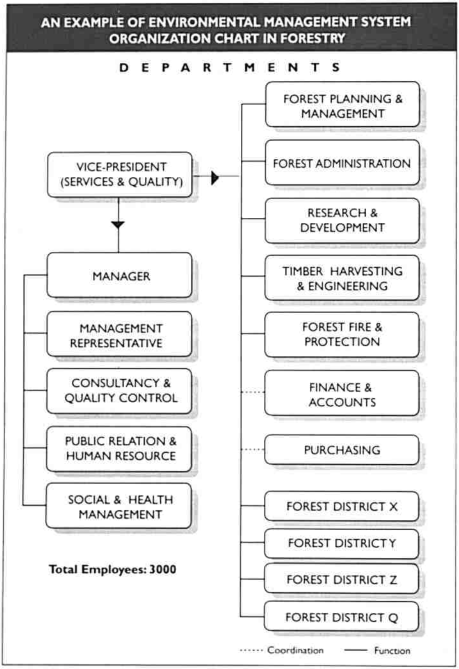
1. Oil change for all heavy vehicles (bulldozers, logging trucks, etc.) is done, for example, every 5000km and other machinery every 10,000km; Oil is accumulated and sent to the treatment plant.
2. Information data sheet on the uses of chemicals and their safety signs must be strategically displayed.
3. The DOs and DON'Ts lists on the use of chemicals must also be displayed.
4. Toxic and non-toxic chemicals must be stored separately.
5. Compliance of the ground water or stream water safety is to be evaluated once in three months.

Implementation and Operation (ISO Clause 4.4)

For effective implementation and operation of an Environmental Management System, an organization must develop appropriate capabilities and support mechanisms to achieve its environmental policy, objectives and targets.

Structure and Responsibility (ISO Clause 4.4.1)

The successful implementation of EMS starts with the commitment from the highest level of management, down to the lowest levels, that is, it calls for full commitment of all employees of the organization. Other areas of the organization, such as the administrative unit and the management may be involved by providing the resources - skills, technology and finance - required for the implementation and control of its EMS.



BOX 10

An example of structure and responsibility can be viewed from an organizational chart as in Box 10.

Training, Awareness and Competence (ISO Clause 4.4.2)

The organization shall identify training needs for all its employees and all contractors working on its behalf should be able to show that their employees have had the required training in activities that may create a significant impact on the environment.

In the same example on minimizing soil erosion and preventing chemical contamination on water supply, the organization can provide the following:

1. Improvisation of proper handling techniques of chemicals and fuel
2. Ensurance that harvesting personnel and contractors have an adequate level of expertise and are subject to appropriate training in, for example, low impact logging techniques and proper waterbars and cross-drain construction on the road
3. Appropriate sized stream and lake buffers that are not deliberately disturbed
4. No ponding (i.e. water logged areas) behind stream and river crossing

Another example and a frequently overlooked activity is training on forest fire fighting. The following could be instituted:

1. Enforce manning procedure of fire tower inside the forest plantation, even during periods when a forest fire is least expected.
2. Institute forest fire fighting drills, at least once every 6 months.
3. Enforce preventive maintenance of forest fire fighting equipment.

Communication (ISO Clause 4.4.3)

The organization shall establish and maintain procedures for internal communication within the organization and with external interested parties concerning its environmental aspects and environmental management system.

Returning to the example on protecting water supply from contamination, a form of communication with the employees is by

1. displaying information data sheets on the proper use and handling of chemicals and fertilizers, and
2. strategically locating safety signs and instructions dealing with chemical and fuel storage.

Environmental Management System Documentation (ISO Clause 4.4.4)

The organization is required to maintain documents, in paper or electronic form, to describe the core elements of the environmental management system and their interaction and provide direction on where to obtain detailed information on the operation of its environmental management system. As such the organization should have, for examples, organization charts, process information, manning procedure of an activity, on site emergency plans, etc.

Document Control (ISO Clause 4.4.5)

The organization is required to maintain documents for effective implementation of its environmental management system and on its environmental performance. Documentation shall be legible, updated, and readily identifiable.

Operational Control (ISO Clause 4.4.6)

The organization shall identify those operations and activities that are associated with the identified significant environmental aspects in line with its policy, objectives and targets.

An example of a matrix for screening significant environmental impacts of a forest logging operation (FRIM 1997)[18] is given in Table 1.

Emergency Preparedness and Response (ISO Clause 4.4.7)

The organization shall establish and maintain procedures to identify and respond to accidents and emergency situations. It shall test periodically where practicable, review and revise such procedures.

In the above examples of forest fire occurrence and chemical and fuel contamination, the organization should have and display its

1. emergency response chart in case of a forest fire,
2. emergency response chart in case of chemical and fuel explosion, and
3. containment procedures in case of fuel leakage to the ground.

Checking and Corrective Action (ISO Clause 4.5)

This is an important aspect of ISO 14001 processes. After the organization plans and implements its environmental management system, it must check and take the corrective action necessary to conform to its objectives and targets.

Monitoring and Measurement (ISO Clause 4.5.1)

ISO requires an organization to establish and maintain documented procedures to monitor and measure the key characteristics of its operations and activities that can have a significant impact on the environment. Such procedures must be kept in compliance with relevant environmental legislation and regulations.

In the case of forestry operations, including the above example on minimizing erosion, the following could take place:

1. Abandoned roads and landings are monitored and measured for erosion
2. Necessities and effectiveness of waterbars and cross drains are monitored and water flow measured
3. The condition and life span of roads are monitored and its effects on the wear and tear

[18] See footnote 13

Table 1: Matrix for Screening Significant Environmental Impacts of Forest Logging Management

			PROJECT ACTIVITY STAGES																								
			INVENTORY					ROADING						FELLING								POST-FELLING					
			1	2	3	4	5	1	2	3	4	5	6	1	2	3	4	5	6	7	8	1	2	3	4	5	6
ENVIRONMENTAL COMPONENTS – PHYSICO-CHEMICAL	SOIL	Surface Erosion						S	S	S			?			S	S		C						E	E	?
		Landslip						S	S																		
		Slope stability																									
		Soil compaction						X	X							S	X		C							E	
		Soil fertility						X	X							X	X		X								
	Hydrology	Water yield												E													
		Dry season flow						S	S					E		S	X		X							E	
		Stormflow/flood response						S	S								X		X							E	
	Water quality	Sediment load						S	S							S	S		C							E	
		Turbidity						S	S							S	S		C							E	
		Physical quality						S	S							S	S		C							E	
		Chemical quality																			S			S			
		Biological quality																									
	Drainage	Channel morphology						S	S	S																	
		Sedimentation						S	S	S			?			S	S		C							E	
		Drainage pattern						S	S	S																	
	Groundwater	Water table recharge						S	S							S	S		X							E	
		Groundwater quality																									
		Aquifer characteristics																									
		Existing uses																									
	Atmosphere	Local climate																									
		Regional climate																									
		Air pollution (dust, smoke etc.)						S	S				S						S								
	Land use	Adjacent land uses																									
		Downstream land uses																									
BIOLOGICAL	Species and population	Terrestrial vegetation					E	X	X							S	S		X			E	E	E			
		Birds												S													
		Mammals												S													
		Reptiles / Amphibians																									
		Invertebrates												?													
		Fish						?	?																		
		Other aquatic life						?	?																		
	Habitats and communities	Primary forests					E	X	X					S								E	E	E			
		High attitude forests																									
		Rare or residual forest type					E																				
		Seedbank collection												X													
		Aquatic habitat						?	?																		
HUMAN	Health and safety	Domestic water supply						S	S	S						S	S		X								
	Social and economic	Physical safety												S					S								
		Human settlement						S	S					S					S								
		Cultivation areas																	S								
		Forest product collection area						E	E					S													
		Employment generated					E							E													
STAND MGT	Aesthetic	Wilderness						S	S					S													
		Visual quality						X	X																		
		Cultural, historic site						S	S				S	S													
	Silviculture	Sustainability of volume												S								E	E	E			
		Frequency of re-entry																									
		Regeneration potential					E	X	X					E		X	X		X			E	E	E			
		Restocking					E	X	X					S		X	X		X			E	E	E			

KEY

- S POTENTIAL SIGNIFICANT IMPACT, DESIGN SOLUTION IDENTIFIED
- ? ADVERSE IMPACT POTENTIAL BUT INSUFFICIENT INFORMATION
- X RESIDUAL AND SIGNIFICANT ADVERSE IMPACT
- E SIGNIFICANT ENVIRONMENTAL ENHANCEMENT
- C POTENTIALLY SIGNIFICANT CUMULATIVE IMPACT

Note: blank boxes indicate the respective activity has no direct impact

PROJECT ACTIVITIES

INVENTORY
1. Access road
2. Tracts
3. Base camps
4. Waste disposal
5. Cliber cutting

POST FELLING
1. Post-F inventory
2. Enrichment planting
3. Girdling (GCL)
4. Water bar on logging road
5. Soil improvement works
6. Encroachment

ROADING
1. Slope cutting
2. Contouring
3. Stream crossing
4. Cross-drains side ditch
5. Erosion control measures
6. Drilling and blasting

FELLING
1. Felling
2. Buckinge camps Skidding and hauling
3. Landing
4. Loading
5. Log transportation and subsequent road users
6. Base camps
7. Waste and chemical disposal

(Source: FRIM, 1997)

of logging trucks measured

4. Gullies on the roads are monitored and turbidity and suspended solids in the stream or river resulting from erosion due to logging measured
5. Color of water in the river and its pH resulting from erosion due to logging and road construction are measured and monitored

The procedures to monitor and measure some of the above environmental impacts of forestry operations can be found in *Techniques or Methods of Rapid Assessment* (see footnote 13).

Non-conformance and Corrective and Preventive Action (ISO Clause 4.5.2)

ISO 14001 requires an organization to establish and maintain procedures for investigating and correcting non-conformance. It also calls for identifying the cause of non-conformance, implementing its corrective actions, avoiding repetition of the non-conformance, and recording any changes in its corrective actions.

One good example in forestry is the issue of land tenure. Security of forest land tenure is an important element in ensuring sustainable forest management. Land tenure must be legal and clear. Provision for continuing land tenure in perpetuity must be recognized and identified. Therefore it is important to

1. provide evidence of legal and clear land tenure,
2. institute options and legal requirements and prepare mitigating measures in case of long term land tenure cannot be secured, and
3. provide corrective action if land tenure conflict with local people cannot be solved within the shortest time possible.

Referring to the example in section on **Monitoring and Measurement**, the organization should take, for example

1. corrective measures to reduce erosion,
2. preventive maintenance on roads and on increasing life span of trucks due to over-loading, and
3. corrective measures to avoid slope failure.

Records (ISO Clause 4.5.3)

ISO 14001 requires an organization to establish and maintain procedures for identification, maintenance and disposition of its environmental records, such as complaints, training, inspection and calibration, and significant environmental impacts records; process, product, and contractor and supplier information; and last but not least, results of audit and management reviews.

These records should be readily retrievable and protected against any form of damage.

Environmental Management System Audit (ISO Clause 4.5.4)

In order to ensure that an organization's EMS is properly executed, ISO 14001 requires comprehensive, impartial and objective auditing. This is to ascertain that the organization's forest management policy, objectives and targets are being met or achieved. The audit program shall cover the scope, frequency, methodology, responsibility, and communication of the results of an audit.

Personnel from within the organization may perform an audit. It can also by done by external personnel or a qualified management company to certify conformance with ISO 14001. In conducting environmental auditing, attention should be drawn to the various **Guidelines for Environmental Auditing, i.e. ISO 14010, 14011 and 14012,** even though ISO 14001 does not specify their use.

Management Review (ISO Clause 4.6)

For any organization to maintain its commitment to continual improvement, suitability, adequacy, and effectiveness of the environmental management system, and hence its performance, the management should review and evaluate the environmental management system periodically, taking into account changing conditions and information and results from audits.

Management review would give the opportunity to an organization to address the need for various changes to its environmental management system policy, objectives and targets. The review shall be documented.

A forestry organization may form, for example a *Technical Review Committee* to oversee the review of results of the audit on the environmental training program or its research and development program and to prepare for initiation of a new cycle of review and auditing. The review will allow the management to keep abreast of changing legal requirements, advances in science and technology, and new developments in forestry performance standards, including principles, criteria and indicators for sustainable forest management.

CONCLUSION

One can conclude that the goal of an environmental management system in certification of forest management is to improve forestry practices over time. Today, with a more environmentally conscious public and NGOs, the demand for good (quality) forest management and hence sustainable forest management is of paramount importance. The attraction of ISO 14001 for many forestry organizations is that it can be used by any organization that, as a minimum, makes a commitment to legal compliance and meets the requirements of the standards.

While the initiative of ISO/TC 207/WG2 Forestry to produce a bridging is in progress, many countries and private forestry organizations worldwide on the other hand have paved the way for certification of forest management (or timber certification) in accordance with the existing principles, criteria, and indicators as their performance standards. It is also recognized that many forestry organizations may have problems in coping with various challenges to implementing ISO 14001 EMS standards in forestry. Nevertheless, certification is market driven and hence they have to prepare for it. Organizations can then set their own environmental policy, objectives and targets that are appropriate to their forest management objectives, scale of operation, cultural and political environment, and the magnitude of environmental aspects and impacts, consistent with generally and professionally accepted forestry performance standards.

Finally, it is also recognized that achieving certification of good forest management in all aspects of a forestry organization in one go could be difficult. However, under the ISO 14001 a forestry organization may choose to have its EMS certified to only certain parts or aspects of that organization, i.e. "phase-by-phase" approach to certification. We should accept this "phased" approach as incentives toward continual improvement of an organization's activities. But at the same time, we must note with apprehension the possibility of wrongful and/or misleading claims by organizations (such as through advertisements, etc.) to achieving a total sustainable forest management, when only a certain forestry operation (part/aspect) of that organization is actually EMS certified.

It is hoped that this chapter has provided some guidelines to achieving certification of forest management using ISO 14001 EMS. More important, it is not the purpose of this chapter to create the impression that by conforming with ISO 14001 EMS in only one or two forestry operations and taking into consideration the relevant forestry related information, a forestry organization would be fully certified and hence can claim to be practicing sustainable forest management *in toto.*

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7 ENVIRONMENTAL AUDITING

HUSSEIN RAHMAT

Environmental Auditing began as a means of checking compliance with environmental legislation. Today it is recognized as an invaluable tool for management to gauge the efficiency of its management system. Auditing the management system has many benefits in addition to its role in ensuring compliance to legislation. These include improving environmental performance through monitoring the effectiveness of the management system, increasing the organization's knowledge of itself and its activities thus increasing its ability to continually improve. It also increases the organization's ability to identify and control specific problems thus minimizing future potential liabilities. The process also has the effect of motivating the workforce through demonstrating management commitment to improve the state of working conditions. In the end all of these will help reduce costs for the organization.

Many organizations are now implementing the ISO 14000 Environmental Management System. ISO 14000 Environmental Management System is a quality management system as applied to the management of the environment. The System itself is derived from the concept of Deming's Plan-Do-Check and Act (PDCA) cycle of quality management. Auditing is part of the Check part of that PDCA cycle. Auditing can therefore be seen from the angle of quality management. Its function in an Environmental Management System is that once an Environmental Management System is in place, the organization has to verify that the system is followed, is working and has no deficiencies. The audit is meant to provide that feedback to management. Not only will management detect deficiencies in the management system through auditing but it will also assist it in its effort to continually improve the Environmental Management System.

The rest of this chapter will discuss environmental auditing in the context of ISO 14000 as this Environmental Management System standard has been accepted internationally. It should form the bulk of environmental auditing requirements in the future.

WHAT IS AN ENVIRONMENTAL AUDIT?

An environmental audit, as defined in ISO 14010 is a systematic, documented verification process of objectively obtaining and evaluating audit evidence to determine whether specified environmental activities, events, conditions, management systems, or information about these matters conform with audit criteria, and communicating the results of this process". This means that it is a tool for assessing how well the Environmental Management System is functioning and evaluating how well the environmental organization, management and equipment are performing to safeguard the environment. It facilitates management in re-formulating the organization's policies.

For an Environmental Management System audit program to be effective, the organizations should develop a procedure for conducting the audit. In this regard the existence of ISO 14010 and ISO 14011 guidelines are of great help. Based on these guides management will then undertake certain other activities:

1. Establishing an appropriate audit frequency
2. Training its internal auditors
3. Maintaining audit records
4. Acting on the audit results during management review of the Environmental Management System

The latter point is a key issue in the context of ISO 14000 Environmental Management System. The results of an EMS audit, especially if it is an internal audit, should finally be linked to the Corrective Action requirements of the Environmental Management System. If necessary they are to be further linked to the Environmental Management System Objectives and Targets and Environmental Management Program(s).

THE ISO ENVIRONMENTAL AUDIT GUIDELINES

An environmental audit is guided by the set of complementary international standards within the ISO 14000 family of international standards. The series of standards are as follows:

1. ISO 14010 Guidelines for environmental auditing - General principles of environmental auditing
2. ISO 14011 Guidelines for environmental auditing - Audit procedures - Auditing of environmental management systems
3. ISO 14012 Guidelines for environmental auditing - Qualification criteria for environmental auditors

It is to be noted that the ISO 14010 guidelines provide general principles of environmental auditing that are applicable to all types of environmental audits whilst the ISO 14011 are limited to ISO 14000 Environmental Management System. For this reason there are now moves to establish other auditing guidelines for specific purposes such as for site assessment.

The scope of environmental audits could be for the whole organization at one time, phased to consider parts of the site, departments, or operations separately. Perhaps it could be based on indications from the initial environmental review and operation of the Environmental Management System itself.

GENERAL PRINCIPLES OF ENVIRONMENTAL AUDITING

The general principles of environmental auditing, like those of any other kind of audit, are geared to ensure the reliability of audit findings and their conclusions. The points of focus as enumerated in ISO 14010 are as follows:

1. Scope requirements for the audit of the audit team
2. Objectivity, independence and competence of the audit team
3. Due professional care
4. Systematic procedures
5. Audit criteria, evidence and findings
6. Audit report

Scope Requirements for the Audit

An audit should have an objective that is agreed upon by the parties involved, that is the auditor and the auditee, before any audit is carried out. Hence the scope of the audit should be specific, pre-determined and should cover the extent and physical boundaries of the audit.

Objectivity, Independence and Competence of the Audit Team

The members of the audit team should be independent of the activities that they audit to ensure the objectivity of the audit, its findings and conclusions.

They should be free from bias and any potential conflict of interest throughout the audit process. For example in a third party audit, the client has the discretion of choosing to include an internal audit team to carry out the audit. In that case the audit team member or members should not be accountable to those directly responsible for the subject matter being audited.

The audit team should be competent enough to carry out the audit. The team as a whole should possess an appropriate combination of knowledge, skills and experience among them to carry out the audit.

Due Professional Care

At all times auditors should use the care, diligence, skill and judgement expected of any auditor in similar circumstances. In particular confidentiality and discretion should be maintained among the audit team members and the client. Unless required by law, the audit team members should not disclose information or documents obtained during the audit, or the final report, to any third party, without the expressed approval of the client and where appropriate, the approval of the auditee.

To enhance the audit process the Auditor should follow procedures that provide for quality assurance.

Systematic Procedures

Environmental audit should be conducted according to documented and well-defined methodologies and systematic procedures. Guidelines for conducting an environmental management system (EMS) audit are given in ISO 14011. The EMS audit should then be conducted in accordance with these general guidelines.

Whatever the audit, the methodologies and procedures should be kept consistent. The procedures for one type of environmental audit from those of another only where it is essential to the specific character of a given type of environmental audit. Examples are compliance audits and site assessment audits.

Audit Criteria, Evidence and Findings

An audit needs to have a framework on which the audit can be based. Therefore, in preparation for an environmental audit the determination of audit criteria should be one of the first steps.

The lead auditor and the client should agree on the details of these. In turn the auditee should be informed of the requirements.

During the audit, information should be collected based on these criteria and data are analyzed, interpreted and documented accordingly. The information derived from these are to be used as audit evidence to determine whether the audit criteria are met.

Audit evidence should be of such a quality and quantity that competent environmental auditors working independently of each other would reach similar audit findings from evaluating the same audit evidence against the same audit criteria.

Reliability of Audit Findings and Conclusions

The environmental auditing process should be designed to provide the client and auditor with the desired level of confidence in the reliability of the audit findings and any audit conclusions.

The audit evidence collected during an environmental audit will inevitably be only a sample of the information available, partly due to the fact that an environmental audit is conducted during a limited period of time and with limited resources. There is therefore an element of uncertainty inherent in all environmental audits and all users of the results of environmental audits should be aware of this uncertainty.

The environmental auditor should consider the limitations associated with the audit evidence collected during the audit, and recognize this uncertainty in his findings and his conclusions. He should take these factors into account in planning and executing the audit.

The environmental auditor should endeavor to obtain sufficient audit evidence so that significant individual audit findings and aggregates of less-significant findings, both of which may affect any audit conclusions, are taken into account.

Audit Report

The audit findings and summary should be delivered to the client in a written report. Unless specifically excluded by the client, the auditee should receive a copy of the audit report.

The following audit related items may be included in audit reports:

1. The identification of the organization audited and the client
2. The agreed objectives and scope of the audit
3. The agreed criteria against which the audit was conducted
4. The period covered by the audit and the date(s) the audit was conducted
5. The identification of the audit team members
6. The identification of the auditee's representatives participating in the audit
7. A statement of the confidential nature of the contents
8. The distribution list for the audit report
9. A summary of the audit process including any obstacles encountered
10. The audit conclusions

The lead auditor in consultation with the client should determine which of these items, together with any additional items, will be included in the report.

ENVIRONMENTAL MANAGEMENT SYSTEM AUDITING PROCEDURE

The objective of environmental management system auditing is to verify that an organization's environmental management system is operating as designed. The audit is either for the purpose of certification or for feedback to management so that it can take corrective action for any deficiency in its operation or for it to continue to improve its management system. In either case an environmental management system audit is part and parcel of ISO 14001 environmental management system standard specification.

ISO 14000 requires that auditing of its environmental management system must be based on a process that is systematic and its findings and conclusions are objective and reliable. To enable an organization to do this a set of procedures has been established in the form of ISO 14011 which in turn is based on the auditing principles guideline described in ISO 14010.

The ISO 14011 procedure stresses that an environmental management system audit needs to have specific objectives. Below are examples of such objectives:

1. To ensure conformance with requirements of an environmental management system
2. To determine whether an environmental management system has been properly implemented and maintained
3. To identify areas of potential improvements
4. To assess the ability of the internal management review process to ensure the continuing suitability and effectiveness of the environmental management system
5. To evaluate the environmental management system of an organization for contractual purposes

The guideline lays down the roles and responsibilities for parties that are involved during an audit, the protocol of the audit, how the results of audit findings are to be assembled into a report and finally how the reports are to be distributed.

ROLES AND RESPONSIBILITIES OF PARTIES IN AN ENVIRONMENTAL MANAGEMENT SYSTEM AUDIT

There are many players involved during an audit process. The roles and responsibilities for the lead auditor, auditor, audit team, client and auditee have been identified in ISO 14011. Brief descriptions are as follows:

Lead Auditor

The lead auditor has most responsibility in any audit. This includes, among others, ensuring the efficient and effective conduct and completion of the audit within the audit scope and plan approved by the client. He is also responsible for collecting relevant information, forming an audit team and directing the team activities, preparing and coordinating working documents, procedures, audit plans, resolving problems that arise, determining whether the requirements of ISO 14010 have been met, notifying critical nonconformances, recognizing when audit objectives become unattainable and reporting the reasons, making recommendations for improvements to the EMS (if agreed in the scope of the audit) and reporting within the time agreed upon.

Auditor

The auditor works in support of the Lead Auditor and is under the direction of the latter. His other duties include planning and carrying out the assigned task objectively, effectively and efficiently, collecting and analysing relevant and sufficient audit evidence, preparing working documents, documenting individual audit findings and finally assisting the Lead Auditor in writing the audit report.

Audit Team

The Audit Team must work as a unit and the members must complement each other. It is the task of the Lead Auditor to identify the members.

The Lead Auditor's task in this respect is two-fold:

1. To ensure that team members have the experience and expertise needed to conduct an audit in the organization, on the processes or functions audited. He has to verify that the team has:

   a. the right qualifications e.g. as given in ISO 14012,
   b. the appropriate number of members with the necessary language skills and expertise. required for the audit, and
   c. no potential conflict of interest between the audit team members and the auditee

2. To ensure that the overall requirements of the audit are met. These include:

a. requirements of clients and certification and accreditation bodies, and

b. inclusion of technical experts and auditors-in-training that are acceptable to the client, auditee and lead auditor in the audit team.

Client

The client and the auditee could be one and the same. The audit team works for the client, whose responsibilities and activities should include the determination of the need for the audit in the first place. The client should be the initiator of the auditing process and responsible for contacting the auditee, defining the audit objectives, selecting the lead auditor and, if appropriate, involved in selecting the audit team. He should then provide authority, resources and together with the lead auditor, determine the scope of the audit, and approve the EMS audit criteria and the audit plan. He receives the audit report and oversees its distribution.

Auditee

As mentioned earlier the auditee and the client could be one and the same. In either case he should cooperate with the audit team and he should provide facilities needed for the audit including access to facilities, personnel, information and records as requested. He should appoint staff to act as guides to sites and to ensure that the audit team is aware of health, safety and other requirements.

Unless specifically excluded by the client he should also receive a copy of the audit report. Although the "auditee" has been personalized as a "he" in the context of this chapter, in actuality the "auditee" is the "organization" to be audited.

PHASES IN THE AUDIT PROCESS

There are five distinct phases in the audit process: initiating, preparing and conducting the audit and finally writing and distributing audit reports.

Initiating the Audit

Audit Scope

Before an audit is carried out, the scope of the audit has to be determined by the lead auditor. The lead auditor must consult with the auditee to get the latter's concurrence. The scope determination includes agreement on the extent and boundaries of the audit such as physical location, organizational activities as well as the manner of reporting. During the process of auditing the scope may need to be changed either because of something new discovered or for another reason. Such changes to the scope require the agreement of the client and the lead auditor.

The required resources such as personnel, time and money, which have been agreed upon commensurating with the scope of the audit should be made available.

Preliminary Document Review

An environmental management system such as ISO 14001 is specific in its requirements as to what an organization should have and do. Some of these specific requirements include the existence of such things as an environmental policy statement, documentation on the organization's environmental management system, a statement of the organization's objectives and targets, an outline of environmental program and related records or manuals. The lead auditor should first review the existence and the adequacy of these with respect to the requirements of the standard. If these are not adequate, the auditee should be informed and all auditing processes should be stopped until which time the requirements are met.

Preparing for the Audit

In preparing for the audit several things need to be organized ahead of time to enable the audit to be carried out efficiently. An audit plan needs to be prepared, members of the audit team must be given their individual assignments and the working documents need to be readied.

The audit plan should be flexible to permit changes in audit information and use of resources. The audit plan should include statements of audit objectives, scope and criteria, should identify the functional units to be audited including those having direct responsibility for the auditee's environmental management system and should highlight EMS elements that are of high audit priority, the procedures for auditing them and the EMS reference documents.

If applicable, whenever the audit is to take place in an area where a different language is used, such as in an organization where a different ethnic group is prevalent then a statement on the working and reporting languages of the audit could be appropriate.

The expected time and duration for major audit activities, the dates and places where the audit is to be conducted and identification of audit-team members are also part of the information in the plan.

The audit plan should be reviewed and approved by the client. It should also be communicated to the client, the audit-team members and the auditee. If there is any objection from the auditee, the lead auditor should resolve this with the auditee and the client before continuing with the audit. Likewise if there are any revision to the plan, it should first be agreed upon among the parties before proceeding.

Audit-team Assignments

Team members should be assigned their duties in consultation with them and instructed on the procedure to be followed for specific environmental management system elements, functions, or activities to audit. These can be changed by the lead auditor during the audit to ensure the optimal achievement of the audit objectives.

Working Documents

The working documents required to facilitate the audit include

1. forms for documenting supporting audit evidence and audit findings,

2. procedures and checklists used for evaluating environmental management system elements, and
3. records of meetings.

Working documents should be maintained until completion of the audit. Any confidential or proprietary information should be safeguarded by the audit team members.

Conducting the Audit

Several key activities are identified for this phase of the audit. These include an opening meeting with the auditee at the latter's premises, the collection of evidence, the report of findings and finally a closing meeting.

The opening meeting is necessary for the purpose of communicating with the auditee in an official manner. The introduction of the audit team members to the auditee establishes an official link which promotes auditee participation during the audit. This forum provides an avenue for reviewing the scope of the audit, presenting the objectives of the audit and the audit plan and providing the auditee with a short summary of the methods and procedures to be used to in the audit. It also enables both parties to come to an agreement on the audit timetable and to confirm the time and date of the closing meeting.

The forum provides the opportunity for the auditee to confirm which facilities are to be made available to the team and to review relevant site safety and emergency procedures for the audit team.

Collecting Audit Evidence

When collecting evidence the team must ensure that these are sufficient to determine whether the auditee's environmental management system conforms to the Environmental Management System audit criteria.

Audit evidence is collected through interviews with key personnel. These interviews should be pre-planned. Further evidence is collected through examination of documents and observation of activities and conditions. Indications of non-conformity to the environmental management system audit criteria must be recorded.

Information gained through interviews should be verified from independent sources such as: observations of what actually is happening on site, inspection of records and results of existing measurements. Non-verifiable statements should be identified as such.

The audit team should examine the basis of relevant sampling programs and the procedures for ensuring effective quality control of sampling and measurement processes used by the auditee as part of its environmental management system activities. The audit team should review all of their audit evidence to determine where the Environmental Management System does not conform to the environmental management system audit criteria.

The audit team should ensure that findings of non-conformity are documented in a clear and concise manner and are supported by audit evidence. Members should review audit findings with the responsible auditee manager to obtain acknowledgement of the factual basis of all findings of non-conformity. Details of audit findings of conformity may also be documented if this is within the agreed scope, but due care must be taken to avoid any implication of absolute assurance.

Closing Meeting

A closing meeting is held to ensure that the auditee has clearly understood the audit findings and to obtain acknowledgement that the audit findings are factual. For this reason, the audit team should always hold a closing meeting with the auditee's management and those responsible for the functions audited before preparing an audit report.

If possible, all disagreements should be resolved, before the lead auditor issues the audit report. The final decision on the description of the audit findings and their significance ultimately rests with the lead auditor even though the auditee or client may disagree with these findings.

Preparation of Audit Report

The lead auditor must ensure that the audit report is complete. The content of the report should be according to what was determined earlier in the audit plan and it should be in accordance with the guidelines in ISO 14010 on this issue. Any changes to be made during the preparation of the report should be agreed upon by the parties concerned.

An essential requirement of the audit report is that it should be dated and signed by the lead auditor. The audit findings contained therein should be referenced to the supporting evidence. Preferably there should also be a summary.

The report may also include the identification of the organization and the client, the agreed objectives, scope and plan, the agreed criteria, including a list of reference documents against which the audit was conducted and the period of time covered by the audit.

Another requirement is that the people involved in the audit should be identified. Those to be identified include the auditee's representatives and the audit-team members. A statement on confidentiality should appear. Finally, the distribution list should be given.

The body of the report should contain a summary of the audit process including any obstacles encountered during the audit. The details of findings and audit conclusions relating to conformance to the environmental management system audit criteria, proper implementation and maintenance of the system and the capacity of the internal review process to ensure the continuing suitability and effectiveness of the environmental management system should also be included.

Distribution of the Audit Report

The audit report should be issued within the agreed time period as laid out in the audit plan. If this is not possible, the reasons for the delay should be formally communicated to both the client and the auditee. A revised issue date should be established.

The lead auditor should send the audit report to the client. The client, in accordance with the audit plan should have determined the distribution list for further copies of the reports. The auditee should receive a copy of the report unless specifically excluded by the client initially. However, any distribution outside the auditee's organization requires the auditee's permission.

It should be noted that the audit report is the sole property of the client, therefore confidentiality must be respected and appropriately safeguarded by the auditors and all report recipients.

Document Retention

It is a requirement that all working documents, drafts and final reports pertaining to the audit should be retained as agreed by the client, the lead auditor and the auditee, and in accordance with any applicable requirements.

PRACTICAL ASPECTS OF AUDITING

Other Types of Environmental Audits

Environmental audits began as legal compliance audits. As time passed various types of audits have been identified. Environmental audits can be used to verify that the company's environmental statement gives a fair representation of its actual performance. This is an important issue in some countries especially in Europe. Audits are also used to assess potential legal liabilities or expenditure as for example in site assessments. The latter is the subject of ISO 14015 guidelines on site assessments and entities. Regardless of the type of audit, the general principles for auditing should remain the same as laid down in ISO 14010 Guidelines on Environmental Auditing. There may be slight variations in the procedures as dictated by the type of environmental audits.

Environmental management system audit is becoming more important because of the number of organizations certifying to ISO 14001 Environmental Management System standards. Thus it is crucial that information on how to carry out an environmental management system audit be widely available because of the requirement that auditing be carried out at various stages of the implementation of an environmental management system. The objective of the audit is to check and to verify conformance to an environmental management system standard first. This includes monitoring the progress of the organization in implementing its environmental policy, its objectives and targets and compliance to law and regulation. Thereafter the purpose of the audit is to continually monitor the performance of an organization's environmental management system.

Steps in the Audit Process

The steps in an auditing process are as depicted in Figure 1 which follows the ISO 14011 Guidelines on auditing an Environmental Management System.

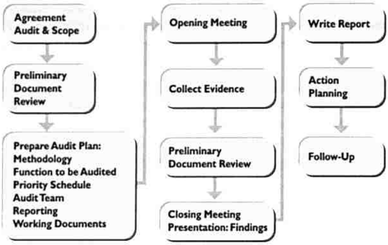

Figure 1 : Steps in the Audit Process

Preparation for the Audit

Generally the auditing process begins by identifying the audit team leader who will select the audit team independently or jointly with the client. The leader will identify the number of team members and their qualifications. If there are not enough resources available in terms of manpower, expertise, time and financial support, it is better not to undertake the audit. The audit may not be as thorough or there may not be sufficient evidence collected to ensure that the audit is as objective as it ought to be. Once the decision is made to conduct the audit, the audit team must ensure that top management supports the audit especially in the case of an internal audit. The organization to be audited and its relevant employees must be made aware of the audit, procedures, the objectives and requirements. This will help to ensure the support and cooperation of those parties. In some cases the audit team members themselves need to be trained.

The preparation involves the gathering of as much information as possible about the organization to be audited. This is in order to develop a systematic plan consisting of a comprehensive program and timetable of the audit activities.

Findings of previous audits should be made available to the team. Team members should have an understanding of the operations and processes at the site. They should also be aware of the nature of raw materials used, products, by-products, emission and discharges made from the site.

Special attention is to be given to the site and its surroundings with respect to any special legal provisions that apply to it, such as its nearness to a nature sanctuary and other potential issues such as political sensitivities.

A pertinent issue for the audit team is their own health and safety when carrying out an audit. The site may be hazardous and may have special requirements such as exist in nuclear plants. The audit team needs to be prepared in terms of what provisions are necessary and who is to provide them. These may include regulations concerning safety clothing, use of photographic equipment or personal protective equipment and respiratory equipment required during entry into confined spaces and monitoring of hazardous exposure to gases or radiation (radio-activity). The team needs to ensure that there is access to communication equipment and to a hospital if it is thought that these may be required during an audit.

Preparing the Audit Plan

The audit plan is the master plan. The plan includes audit objectives, the scope and criteria of the audit and the functional units to be audited. Special attention is to be given to those units having direct responsibilities for the auditee's environmental management system, to environmental management system elements that are of high audit priority (see below) and the procedures for auditing these. EMS reference documents, the working and reporting languages, duty assignment of audit team members, the expected time, duration, dates and places for major audit activities and other pertinent details are matters to be given attention.

EMS elements that are of high environmental concern during an audit are:

1. Compliance with laws and regulations
2. Management of areas of significant risks including:
   a. Excessive use of raw materials, resources and hazardous substances
   b. Management of waste and atmospheric pollution
   c. Contamination of soil, ground water and rivers
   d. Exposure of workers and the community to environmental hazards
3. Assessment of adequacy and suitability of the organization's internal management controls and practices to address the above issues.

Documents to be Prepared

Documents to be prepared as part of the plan should include a trail plan to guide the audit team in its investigation, an interview plan which should synchronize with the trail plan, a safety and health plan which is required to protect the team during its investigation activities into hazardous areas and enclosures, stationery (including the ubiquitous clip board, water proofed if possible), questionnaires and forms.

Other preparations include a listing of topics to be covered during the audit questions to be asked, regulations to be followed, standards applicable to the site and the organization and supplementary information such as tables, guidelines, standards etc. to be used as reference during the audit.

Questionnaires and forms should be well constructed, easy to complete, and, most importantly, easy to analyze.

The details of a trail plan include the inspection sequence to be followed beginning from the incoming raw materials leading to the process areas and the routes taken by waste into storage or disposal areas, discharges and emission. The audit team must inspect the whole site and not just the confines of a plant. The trail plan, the interview plan and the inspection plan must synchronized to be effective.

Interviews are an integral part of an audit. The purpose is to gauge the level of understanding and awareness of relevant issues affecting the management system. It is also to gauge the attitudes, skills, knowledge and understanding of employees, to get a better picture of what transpires in the organization and to assess if there is any hidden agenda that could be detrimental to the subject matter of the audit.

The interview plan identifies those to be interviewed in one-to-one meetings at all level from management to operations. The plan should include the format of the questions to be fielded and the method for recording the interviews. The interviews should cover key issues. Individuals should not be identified in the audit report.

Interviewing strategy should be aimed at extracting the most relevant and pertinent information from each level of management. For instance interviews of executives should be on awareness of the organization's environmental policy, instructions and programs derived from the organization's management while operators should be queried on training, procedures and equipment.

The questions should be geared towards accumulating information in order to arrive at a conclusion. There should not be any "open-ended" questions.

Protocol of the Audit

Apart from the process of preparing the checklist and the plan of an audit, there is the conceptual process of assessing the protocol or the formalities of conducting an environmental audit. The formalities may vary depending on the type of audit to be undertaken.

The protocol for an environmental management system audit may include the following:

1. Review of significant environmental aspects of the organization to determine what they are and whether they have been identified systematically and comprehensively
2. Review of the environmental policy, objectives and targets to ensure that they are pertinent to the organization and to determine whether there is real commitment to them
3. Establishment of whether relevant legal and other standards requirements have been identified, incorporated into programs and complied with
4. Availability of an environmental management program
5. Determination of whether the internal environmental management processes had included employee involvement, communications and training
6. Inspection of environmental management system documents, procedures and records
7. Inspection of environmental performance data (records)
8. Records of improvement in environmental performance and the process of corrective action and management review
9. Identification of negative or " bad" news, complaints, nonconformances

Opening Meeting and Audit Preliminaries

Having an introductory meeting with auditee managers is crucial in that it lays the foundation for the subsequent audit activities. Agreement on and clarification of the scope, criteria and audit rationale and processes are discussed. Confirmation of auditee cooperation and availability of facilities for the audit process is determined. An obvious purpose of the meeting is that both parties come to know each other and thus a formal link between both are established.

Auditee's Coordinator

At the opening meeting the auditee's coordinator is identified and he will be the focal person for the audit team. Facilities will be identified and provided for the team by him. He will also escort the audit team and assist in arranging for interviews, access and permit requirements if any. Last but not least, he will assist in providing appropriate safety equipment for audit team members.

Preliminary Environmental Management System Document Review

As the purpose of an environmental management system standard audit is to ensure conformance to the requirements of the standard, therefore there are minimum essential requirements that must be in existence before any serious effort at auditing can be considered. After the opening meeting a preliminary check should be made.

The following are some of the considerations which can determine whether to proceeded with an audit:

1. Are documents adequate?
2. Is there a company's environmental policy?
3. Is there an environmental management program?
4. Are there manuals and records?
5. Are there emergency procedures?

If any of the above is not adequate or not in accordance with the ISO guidelines, the auditee should be informed and all auditing processes should be stopped. Note: Some of these documentation could have been inspected earlier during the audit plan preparation process.

Document Inspection Techniques

There is a need to inspect all the written procedures, monitoring procedures, maintenance procedures, records of monitoring waste, permits and licenses. In the case of major environmental control equipment, the calibration and testing records should be examined.

An important element to be considered is consistency with environmental policy. The procedures should be cross-checked with regulatory requirements for both existing and pending standards, legislation, permits, etc. The date of last entry in records and status of permits and the signatures on them where these are required should be noted. In addition a detailed review of selected portions of these documents should be done.

All records of compliance should be investigated. Procedures, controls and monitoring programs should be examined. The reliability of data and information must be assessed and if necessary measuring is to be conducted.

Collecting Evidence

Collecting evidence is a key activity in an audit. Only with documented evidence can any findings of the audit be considered objective and the conclusion of the audit be reliable. The audit is to be carried out according to the audit plan. Buildings, plant and equipment, materials, waste handling, storage and disposal areas, air and water discharge points are to be inspected. During this inspection situations that are considered extra-ordinary for example unattended overflowing vessels, should be noted. Queries concerning what happens during normal, abnormal and emergency operations, such as when the plant is shut down, started up and experiencing overloads or under loads should be made. Questions of what, where, when, why, who and how should be asked throughout.

It is important not to stick to the obvious and trodden path. Auditors should look under equipment and walkways, over and outside of barricades and enclosed areas including manholes and basements. They should look beyond areas of main activities such as in stores, workshops and laboratories. In these areas, checks for the amount and control of inventory should be made. The team must look for banned and controlled items such as Halon and CFC and query on how chemicals are handled, transported, labeled and note whether there is good housekeeping including segregation of materials and proper displays of signs. Waste disposal method must be observed. They must check that Material Safety Data Sheets (MSDS) are available. Finally, control measures for purchasing in terms of limiting the amount of inventory as well as purchasing of new chemicals that may be under legislative control or voluntary internal control should be examined.

Further attention should also be given to the general areas and the surroundings of the site, e.g. drainage systems and discharge points, evidence of land contamination, odors and visible emissions. The general areas and the neighborhood of the site and general security in terms of fencing and permits of entry to areas under control must be assessed. In this regard, the general behavior of personnel should be noted. The issues here are signs of drunkenness, drug addiction, excessive fatigue and most important of all signs of incompetence.

Closing Meeting

The exit meeting wraps up the main activities of the audit before a final report is made. The meeting should be attended by managers who were identified earlier for the opening meeting and any others who were identified during the course of the audit. The intention of the meeting is for the auditors to summarize audit findings and discuss them with the audittee. The meeting provides an opportunity for the auditee to comment and to make further clarifications. The audittee can also identify any remedial action to be taken. For the auditors the meeting provides the opportunity to acquire agreement with their audit findings from the auditee. The agreements are important but auditors need not always secure auditee agreements on all points.

SUMMARY

Environmental auditing has become increasingly important as more and more organizations are introducing environmental management. This phenomenon is due to their need to improve compliance to legislation, because of increasing pressure from the community in which they operate. Organizations must show proof of good environmental performance and thus to improve their market competitiveness through better management of resources and good corporate image. Quite often organizations have adopted the ISO 14001 Environmental Management System standard as the basis of their environmental management system since it is an internationally recognized management standard as was the ISO 9001 Quality Management System standard before it.

Whether an organization chooses to use the ISO 14000 Environmental Management System or another standard as a basis for the management system for its organization, environmental auditing is a necessity. Auditing is not only a requirement of the Environmental Management System standard for the purposes of certification, it is also a useful adjunct to quality management. Auditing provides feedback for management on whether it is adhering to or deviating from its plan of action and provides information on steps which can be taken to improve its management. The principle of auditing as a tool for management had been identified by Deming in what is now referred to as the PDCA (Plan, Do, Check and Act) Cycle of Management principles. Auditing is the "Check" part of that cycle.

The International Standards Organization (ISO) finds it useful to publish guidelines on auditing. This it has done in the ISO 14010 series of Auditing Guidelines consisting of ISO 14010, ISO 14011 and ISO 14012. The ISO 14010 (Guidelines for Environmental Auditing - General Principles of Environmental Auditing) is meant for general guidance on environmental auditing of any kind. On the other hand The ISO 14011 (Guidelines For Environmental Auditing - Audit Procedures - Auditing of Environmental Management Systems) is a set of procedures to be used to audit an Environmental Management System. It is meant to either audit the Environmental Management System of an organization that has adopted the ISO 14001 Environmental Management System standard and wants to be certified to it or wants to ensure that it is conforming to it in its day-to-day operations. The title of ISO 14012 (Guidelines for Environmental Auditing - Qualification Criteria for Environmental Auditors) is self-explanatory.

The principles set out in ISO 14010 ensure objectivity and independence of the audit and ensure that personnel carrying out the audit are competent. It further states that an Environmental Audit must be carried out with due professional care and use systematic procedures. It emphasizes that an audit should have a clear objective and therefore is to have a predetermined scope and set audit criteria. Audit conclusions must be based on documented evidence to produce reliable findings.

The procedures set out in ISO 14011 are designed so that the principles of auditing as described in ISO 14010 are adhered to. Advanced planning requirements including documenting the actions and events that are to take place during the audit activities are stipulated. The first step in the procedure is the identification of the lead auditor who will then initiate several activities such as identification of the objective, scope and criteria of the audit, formation of a qualified audit team sufficient for carrying out the audit and ensuring

that all resources are available to run a successful audit. He will then communicate these requirements including the proper assignment of duties for all members of the audit team to the parties involved. ISO 14011 also identifies the role and responsibilities of members of the audit team, the client and the auditee.

As much information as possible must be gathered in the planning and preparatory phase of the audit. This involves pertinent information about the site and organization to be audited, prior results of previous audits, legal requirements and standards pertaining to the site and organization, the surroundings and the communities affected and finally provision of documents such as copies of standards and laws required for reference during the audit. Documentation required at this stage are all the plans including audit plans and protocol. Within the plan are trail plans to facilitate scheduling of the investigation visits, interview plans, safety plans and questionnaires and forms to document findings and reports.

Several key activities are identified for the conduct of the audit. These include an opening meeting with the auditee at the latter's premises, the collection of evidence and findings and, finally, a closing meeting.

The collection of evidence is the most important of these activities as it determines the outcome, objectivity, reliability and the conclusion of the audit. Evidence is collected through inspection of documents, interviews, visits and recording of observations. It is here that the skill of the auditor is tested.

A pre-requisite of ISO 14011 auditing, where the auditor is concerned with auditing the environmental management system of the organization, is the inspection of key documents such as policy statements, identification of significant aspects and impacts and environmental programs. The adequacy of these documents should indicate to the lead auditor whether to proceed with the audit or not. If the audit cannot proceed, the auditee should be informed and the audit is abandoned. Another concern of the audit team is whether all the elements of ISO 14001 Environmental Management System have been adequately addressed and complied with. Some of these aspects can be determined through inspection of records and documentation.

Visits, inspections, interviews and observations are equally important. These are the subjects of the earlier planning preparations. All these audit actions, inspections, interviews, etc., must be carried out in a thorough manner, as it is the non-obvious elements that could be neglected by management. At the same time, it is from the non-obvious elements that the auditor can often find his clues to the real situation.

Thoroughness includes examining the entire site rather than just specific activities, looking behind and under equipment, beyond closed doors and fencing, and observing the perimeter of the site and assessing the surroundings, the drainage and discharge points.

Finally the auditor is reminded that the aim of an environmental management system is the control of emission, discharges, wastes and their disposal and exposure of employees, the community and customer to toxicity, ill health and loss of amenities in the short and long term. The audit should address these issues in its conclusion.

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8 ENVIRONMENTAL PERFORMANCE EVALUATION

HASMAH HARUN

This chapter sets out the meaning of Environmental Performance Evaluation (EPE), the EPE process, and how to plan an EPE. It also describes EPE indicators and how to select them. It then describes the development and use of data and information, and the review and improvement of EPE.

INTRODUCTION

More people have become aware of the impacts of activities, products and services on the environment and the responsibilities of the various parties involved. As a result, organizations face increasing pressures to demonstrate sound environmental performance (EP) by controlling those impacts. EPE refers to a tool, which can provide an organization's management with reliable, objective and verifiable information. This information is usually linked to the achievement of an organization's environmental objectives, targets and other environmental performance criteria. It assists management to focus on trends in environmental performance, changes in performance, and the reasons for them. Based on this, the management can then identify areas for improvement. EPE is also an integral part of the process of continual improvement in environmental management.

Most Malaysian organizations are aware of the need to monitor environmental performance in particular those which are subject to the Environmental Quality Act, 1974 and regulations made under the Act. Many practice some form of environmental management, which can be said to have been driven primarily by environmental legislation. On the whole, during the last two decades, environmental management has been mainly in the form of 'end-of-pipe' treatment. Pollution control equipment was required to be installed and discharge standards were imposed for liquid and gaseous emissions to the environment. In the '80s, such an approach was recognized to be inadequate to handle the problems existing then and other new problems emerging from a rapidly developing industrial and urban nation. An "anticipatory" or "preventive" approach was introduced to complement the earlier approach, and tools employed include Environmental Impact Assessment (EIA) and integrated land use planning.

BACKGROUND

The documents related to EPE were developed by ISO/TC 207 Sub-committee (SC 4) for Environmental Performance Evaluation, which is a sub-committee of TC 207 on Environmental Management. SC 4 and its working groups (WGs) have worked to prepare International Standard ISO 14031.

The scope of SC 4 is:

> "Standardization in the field of environmental performance evaluation for use by organisations to measure, assess and communicate their environmental performance for appropriate management purposes".

The scope of ISO 14031 is:

> "to give guidance on the design and use of environmental performance evaluation within an organization".

All organizations, regardless of type, size, location and complexity, can use ISO 14031. The organization does not even have to have an environmental management system in order to use EPE.

ISO 14031 is in actual fact an environmental management tool made available to assist in the implementation of environmental management systems (ISO 14001). In this respect, it can be seen in the light of other tools, i.e. environmental audits which can be carried out to ascertain compliance with defined requirements or life cycle assessment (LCA), a technique which can be used to assess the environmental aspects and impacts of an organization's products and services. ISO 14001 requires an organization to monitor and improve its EMS so that it can continue to improve its performance, and ISO 14031 provides the guidance to the organization on how and what to do in monitoring its performance. It is important to note that an organization does not have to use ISO 14031 to accomplish its review and improvement process. As such ISO 14031 was designed to be applicable in a broad range of situations, in any management system including one that is not based on ISO 14001.

It is important to note the following attributes of ISO 14031:

1. ISO 14031 does not establish environmental performance levels.
2. ISO 14031 is not designed to be used as a specification standard for certification or registration purposes or for the establishment of any other environmental management system conformance requirements.

WHAT IS ENVIRONMENTAL PERFORMANCE EVALUATION (EPE)?

EPE is defined in ISO 14031 as:

> "a process to facilitate management decisions regarding an organization's environmental performance by selecting indicators, collecting and analyzing data, assessing information against environmental performance criteria, reporting and communicating, and periodic review and improvement of this process"

In other words, EPE is a process that the management of an organization can use to get reliable information on a continuous basis for the purpose of checking that the organization's environmental performance is meeting the criteria that it has set. Whether the management finds that the performance has or has not met the criteria, the management can then review and look for ways to improve the process as well as the organization's environmental performance.

EPE is an ongoing internal management process and tool that uses indicators to convey information comparing an organization's past and present environmental performance with its environmental performance criteria.

Elements of an EPE Process

The EPE process consists of

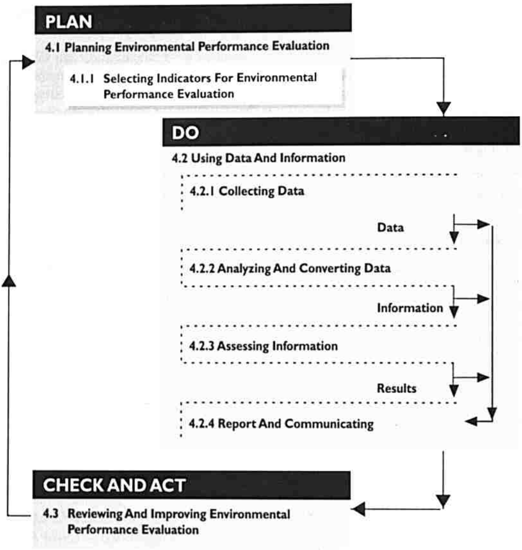
1. selection (e.g. developing or choosing) of indicators for EPE measurement (e.g. collecting data),
2. analysis and conversion of data into information describing the organization's environmental performance,
3. assessment of information describing the organization's environmental performance in comparison with the organization's environmental performance criteria,
4. reporting and communication of information describing the organization's environmental performance, and
5. review and improvement of the EPE process.

An essential feature is that the organization's EPE should be reviewed at regular intervals to improve the process. Figure 1 illustrates the EPE process in line with the 'PLAN-DO-CHECK & ACT' management model.

Results from an EPE

There are a number of things that an organization can do with the results and information generated by an EPE. Such information may assist an organization to

1. determine appropriate measures/actions to achieve its environmental performance criteria,
2. identify opportunities for better management of its environmental aspects (e.g. avoid pollution),
3. track changes in its environmental performance,
4. increase business efficiency, effectiveness and profitability, and
5. identify strategic business opportunities.



(Source: ISO/DIS 14031, 1998)

Figure 1 : Environmental Performance Evaluation

Users of the Results or Reports from an EPE

The immediate users of the results from an EPE are the organization's employees. The information gathered from the EPE can help them in understanding and fulfilling their responsibilities, thereby enabling the organization to achieve its environmental performance criteria. Management will use the reports to make decisions on the company.

The reports may also be communicated to people outside the company or to other interested parties. The decision on whether to communicate the information rests with the management.

Who are the Interested Parties?

Any organization, individuals or groups of individuals may have some interest in the organization's environmental performance depending on several factors such as their activities, services and products, and on how these impact on the environment, their livelihood and their well-being. Interested parties may not even be directly affected by an organization's environmental performance but the interest arises out of the parties' own objectives or mission. For example, a research and development (R & D) institution which is located a distance away from an organization, does not experience any environmental impact of the organization's activities, and does not use the organization's services or products but considers itself an interested party because it is involved in research related to the organization's activities or products.

An organization's interested parties may include

1. investors and potential investors,
2. customers, vendors/suppliers,
3. contractors/sub-contractors,
4. lending institutions (banks) and insurance companies,
5. regulatory/enforcement agencies,
6. neighbouring and regional communities,
7. communications media e.g. press, radio, television,
8. academic and research institutions,
9. environmental and consumer interest groups, and other non-governmental organizations, and
10. the general public.

Information Related to Interested Parties

The information that the interested parties may request include finance-related matters such as

1. costs of environmental management e.g. pollution control equipment,
2. impact on the financial situation of the organization related to past or present environmental liabilities,
3. positive environmental initiatives,
4. investments that improve environmental performance,
5. commercial advantages derived from environmental issues or implementation of environmental management measures, and

6. cost of compliance or non-compliance with environmental regulations or standards.

They may also request for information related to environmental or public policy matters such as

1. health and safety,
2. real and perceived risks to the environment resulting from the organization's activities, including trends over time,
3. impacts on the quality of life (e.g. noise, odour, visual impacts),
4. environmental incidents and complaints,
5. evidence that the organization is fulfilling its environmental commitments,
6. information regarding environmental impacts,
7. quantitative information on environmental loads (e.g. emissions, discharges, and disposal of wastes) including trends over time,
8. biodiversity i.e. abundance, distribution,
9. sustainability,
10. transboundary pollution and other global environmental issues,
11. mpacts of trade on the environment,
12. harmonization of regulatory regimes,
13. environmental characteristics of products and services, and
14. compliance with regulatory requirements.

Obtaining the Views of the Interested Parties

An organization can seek the views of interested parties directly or indirectly through

1. meetings, seminars, workshops,
2. interviews, surveys and questionnaires,
3. participation in industry and public interest groups,
4. market research,
5. employee suggestions,
6. information from the media, and
7. review of reports, statements, programmes of interested parties.

INDICATORS FOR EPE

ISO 14031 describes two general categories of indicators for EPE:

1. Environmental performance indicators (EPIs)
2. Environmental condition indicators (ECIs)

There are two types of EPIs:

1. Management performance indicators (MPIs)
2. Operational performance indicators (OPIs)

MPIs are a type of EPI that provide information about management efforts to influence the environmental performance of the organization's operations. MPIs relate to the policy, people, practices, procedures, decisions and actions at all levels of the organization.

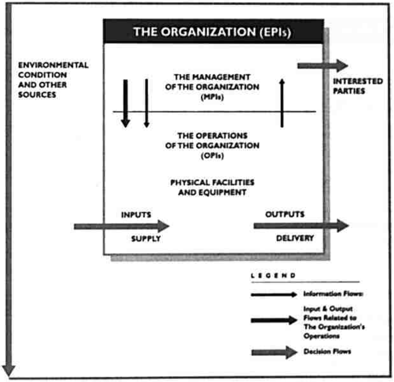
OPIs are a type of EPI that provide information about environmental performance of the operations of the organization. OPIs relate to

1. the design, operation, and maintenance of the organization's physical facilities and equipment,
2. the materials, energy, products, services, wastes, and emissions related to the organization's physical facilities and equipment, and
3. the supply of materials, energy and services to, and the delivery of products, services and wastes from the organization's physical facilities and equipment.

The other type of EPI are the ECIs which provide information about the condition of the environment which may contribute to the evaluation of environmental performance within an organization.

The organization's management and operations are closely related as decisions and actions of the organization's management interact with the organization's operations.

Figure 2 illustrates the interrelationships among an organization's management and operations, and the condition of the environment.



(Source: ISO/DIS 14031, 1998)

Figure 2 - Interrelationship of an Organization's Management and Operation, and the Condition of the Environment

PLANNING ENVIRONMENTAL PERFORMANCE

In planning for EPE, management should consider its organizational structure, overall business strategy, and environmental costs and benefits. The financial, physical, and human resources needed to conduct EPE should be identified and provided by management.

An organization may base its planning and selection of indicators for EPE on

1. consideration of the full range of the organization's activities, products, and services,
2. the significant environmental aspects that it can control and over which it can be expected to have some influence,
3. its environmental policy,
4. its environmental performance criteria,
5. information about the local, regional, national or global environmental conditions,
6. information needed to meet regulatory requirements,
7. ocio-cultural factors, and
8. understanding of the views of interested parties.

In selecting its EPIs, an organization may use different approaches and consider all or some of the following questions:

1. Are the EPIs consistent with the organization's policy?
2. Are they appropriate to the organization, i.e. management, operational, performance?
3. Can they be used to measure performance against its environmental performance criteria?
4. Are they relevant to the interested parties?
5. Are they sensitive to changes to the organization's environmental performance?

IDENTIFICATION OF ENVIRONMENTAL ASPECTS

The identification of an organization's environmental aspects is an important input in planning for EPE. Usually the aspects are in the context of an environmental management system. Guidance on identifying significant environmental aspects in the context of environmental management systems can be found in ISO 14001:1996 and 14004:1996. An organization with an environmental management system in place should evaluate its environmental performance against its environmental policy, objectives, targets and other environmental performance criteria.

What happens when an Organization does not have an Environmental Management System?

An organization without an environmental management system may still use EPE to identify its environmental aspects and to set criteria for its environmental performance. In order to determine the significant aspects, the organization should consider the following factors:

- Legal and regulatory requirements
- Scale of material and energy usage
- Emissions

- Risks
- The condition of the environment
- The possibility of incidents.

In most cases the identification of environmental aspects will focus on the organization's operations.

At first, there may be some difficulty in differentiating between environmental aspect, impact and environmental performance criteria. An organization's environmental aspect is an element of its activities, services or products that can interact with the environment, i.e. which can have some impact on the environment. For example, if one is referring to an organization which provides public transport services, an environmental aspect can be 'emission of smoke and gases from vehicle exhausts'. This environmental aspect would cause an impact on the environment, namely 'deterioration in the air quality'.

It is also important to note that an organization should plan for EPE in conjunction with the setting of its environmental performance criteria, so that the selected indicators for EPE will be appropriate to describe the organization's environmental performance against these criteria.

ESTABLISHMENT OF ENVIRONMENTAL PERFORMANCE CRITERIA

In establishing environmental performance criteria, the best place to start is by looking at the following information:

1. Past performance
2. Legal requirements
3. Best practices
4. Performance data developed by industry and other sector organizations
5. Management reviews and audits
6. The views of interested parties

In the case of the public transport organization mentioned above, environmental performance criteria may be 'compliance with DOE emission standards' and 'zero incidents of failure in emission tests'.

SELECTING INDICATORS FOR ENVIRONMENTAL PERFORMANCE EVALUATION

As mentioned before, in selecting the environmental performance criteria, the choice of indicators must be done carefully so that they are appropriate to the organization and environmental conditions. The purpose of the indicators for EPE is to help to condense relevant data into concise and useful information about management's efforts, the environmental performance of the organization's operation, or the condition of the environment.

An organization should select a sufficient number of relevant indicators to evaluate its environmental performance. The number of selected indicators for EPE will reflect the nature and scale of the organization's operations. The choice of indicators for EPE will also determine which data should be collected or which available data should be used. To avoid unnecessary effort, organizations may wish to use data already available and collected by the organization or by others.

The information conveyed through indicators for EPE can be expressed as direct measures, or as relative, normalized or indexed information. Indicators for EPE may be aggregated or weighted, keeping in mind the nature of the information and its intended use. It is important that aggregation and weighting be done carefully in order to ensure that they are consistent and can be verified, compared, and understood. If assumptions are made in the handling and transformation of data into information and indicators for EPE, they should be clearly understood and noted.

SELECTING MANAGEMENT PERFORMANCE INDICATORS (MPIs)

The management of the organization includes

1. the policies,
2. people,
3. practices,
4. procedures at all levels of the organization, and
5. decisions and actions associated with the organization's environmental aspects.

Efforts and decisions undertaken by the management of the organization may affect the performance of the organization's operations, and therefore may contribute to the overall environmental performance of the organization (See Figure 2).

MPIs should provide information on the organization's capability and efforts in managing matters such as training, legal requirements, resource allocation, documentation, and corrective action which have or can have an influence on the organization's environmental performance. These MPIs should assist evaluation of efforts undertaken by management and actions to improve environmental performance.

For example, MPIs may be used to track

1. implementation and effectiveness of environmental management programs,
2. actions and decisions of management which affect the environmental performance of the organization's operation, and subsequently, the condition of the environment,
3. specific efforts made for the successful environmental management of the organization,
4. environmental management capabilities of the organization, including coping with changing conditions, accomplishment of specific objectives, or solving problems, and
5. compliance with legal and regulatory requirements, and conformance with other requirements.

Apart from the above, MPIs may also be used for

1. prediction of changes in performance,

2. identification of root causes of conformance or non-conformance with environmental criteria,
3. identification of opportunities for preventive or even remedial action.

SELECTING OPERATIONAL PERFORMANCE INDICATORS (OPIs)

The organization's operations include the

1. design, operation and maintenance of the organization's physical facilities and equipment,
2. supply to and delivery from the organization's operations,
3. T materials, energy, and services, used by organization's operations, and
4. products, services, wastes, and emissions resulting from the organization's operations.

Operational Performance Indicators (OPIs) should provide management with information on environmental performance related to

1. the consumption of materials (e.g. processed, recycled, reused, or raw material, natural resources, energy, and services),
2. the products (e.g. main products or by-products) services, wastes, (e.g. solid, liquid, hazardous, non-hazardous, recyclable, reusable), and emissions (e.g. emissions to air, effluents to water or land, noise, vibration, heat, radiation, light) resulting from the organization's operations, and
4. the physical facilities and equipment of the organization, their design, operation and maintenance, as well as the supply to and delivery from the facilities.

SELECTING ENVIRONMENTAL CONDITION INDICATORS (ECIs)

Environmental condition indicators (ECIs) may be at local, regional, national or global levels.

Overall, organizations are encouraged to consider ECIs in their environmental performance evaluation because they provide an environmental context to support the following activities:

1. Identification and control of its significant environmental aspects
2. Selection of MPIs and OPIs
3. Establishment of a baseline against which to measure change
4. Determination of change over time in relation to an on-going environmental program
5. Investigation of possible relationships between environmental condition and the organization's activities, products and services
6. Determination of need for action

An organization may be able to identify a specific environmental condition that is a direct outcome of its own operations. In that event, the organization may wish to link one indicator with one or more other indicators for EPE to relate actions to changes in environmental conditions.

An organization may also find it a difficult task to define ECIs because the organization is not the only source contributing to a particular environmental impact. Apart from multiple sources, there are other factors such as cumulative impacts (additive or interactive), and the effects of temporal or spatial processes.

DEVELOPING AND USING DATA AND INFORMATION

The following activities describe the next step in the EPE process:

1. Measuring (e.g. collecting data)
2. Analyzing and converting data into information describing the organization's environmental performance
3. Assessing information describing the organization's environmental performance in
4. Comparison with the organization's environmental performance criteria
5. Reporting and communicating information describing the organization's environmental performance

COLLECTING DATA

An organization's plans must include the regular collection of data, which would serve as input for calculating values for selected indicators for EPE. Data collection should be planned and carried out systematically from appropriate sources at frequencies consistent with EPE planning.

Any data collected must be reliable. This depends on factors such as availability, adequacy, scientific and statistical validity and verifiability. Data collection should be supported by quality control and quality assurance practices that ensure the data obtained are of the type and quality needed for EPE use. Data collection procedures should include the appropriate identification, filing, storage, retrieval, and deposition of data and information. Such provisions help to ensure the credibility and relevance of EPE to operations.

Sources of Data/Information

An organization may use its own data or data from other sources. Data may be collected from

1. monitoring and measuring,
2. interviews and observations,
3. regulatory reports,
4. inventory and production records,
5. financial and accounting records,
6. environmental review, audit, or assessment reports,
7. environmental training records,
8. scientific/research studies and reports,
9. government agencies, academic institutions and non-governmental organizations,
10. vendors/suppliers and sub-contractors, and
11. customers and consumers

ANALYSING AND CONVERTING DATA

After collection, data are analyzed and converted into information describing the organization's environmental performance, expressed as indicators for EPE. To avoid bias in the results, all relevant and reliable data that have been collected should be considered.

Data analysis may include consideration of the data quality, validity, adequacy, and completeness necessary to produce reliable information.

ASSESSING INFORMATION

After data have been analyzed and converted into performance information, expressed in terms of EPIs or ECIs, they should be compared with the organization's environmental performance criteria. This comparison may indicate improvement, or weaknesses in environmental performance. The results of this comparison may be useful in understanding whether or not the environmental performance criteria are met. The information describing the organization's environmental performance and the results of the comparison, should be reported to management, in order to support appropriate management actions to improve environmental performance.

REPORTING AND COMMUNICATING

Environmental reporting is a tool for providing information describing an organization's environmental performance to external as well as internal interested parties, based on management's assessment of needs, responsibilities and accountability.

Benefits of reporting and communicating may include

1. assisting the organization to achieve its environmental performance criteria,
2. increasing awareness and dialogue about the organization's environmental policies, objectives, targets and other environmental performance criteria,
3. demonstrating the organization's commitment and efforts to improve environmental performance, and
4. demonstrating the organization's responsiveness to concerns and questions about the organization's environmental aspects.

INTERNAL REPORTING AND COMMUNICATING

Within an organization, it is the responsibility of the management to ensure that appropriate and necessary information describing the organization's environmental performance is communicated throughout the organization on a timely basis. Such information will assist employees, contractors, and others related to the organization to fulfill their responsibilities, and the organization to meet its environmental performance criteria.

Examples of information describing the organisation's environmental performance may include

1. status of and trends in the organization's environmental performance,
2. status of environmental legislative and regulatory compliance,

3. status of the organization's conformance with other requirements to which it subscribes,
4. cost savings or other financial results, and
5. opportunities or recommendations to improve an organization's environmental performance.

EXTERNAL REPORTING AND COMMUNICATING

An organization may choose or may be required to issue environmental reports or statements providing information describing its environmental performance to external interested parties. Such reports may include information provided by EPE.

Reporting of environmental performance is not a new exercise for those organizations subject to the Environmental Quality Act, 1974 and other laws, for example the Occupational Safety and Health Act, 1994. Under these laws and their regulations, organizations are usually required to report performance as a condition of approval, or to obtain permit or licence. On carrying out EPE, an organization will have an environmental performance report and the organization will be able to decide on the manner and content of the report that it communicates to external parties. In this case, the organization is reporting its performance against criteria and targets that it has set for itself. It is important to note that the external communication should provide a true and valid picture of the organization's performance, tailored for comprehension by the intended audience and in the final analysis, serve to enhance relations between the organization and the interested parties.

REVIEWING AND IMPROVING ENVIRONMENTAL PERFORMANCE EVALUATION (CHECK & ACT)

In line with the philosophy of continual improvement, an organization's EPE and the results obtained should be reviewed at reasonable intervals in order to identify potential areas for improvement. The areas for improvement may concern the EPE process, the organization's activities, services or products, and the environmental report. This may result in improvement of the organization's management and operations, and contribute to improvements in the condition of the environment.

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Appendix 1

List of Key Terms and Definitions

No.	Term	Definition
1	Environment	Surroundings in which an organization operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelation.
2	Environmental Aspect	Element of an organization's activities, products or services that can interact with the environment.
3	Environmental Condition	Indicator (ECI) Specific expression that provides information about the local, regional, national or global condition of the environment.
4	Environmental Impact	Any change to the environment, whether adverse or beneficial, wholly or partially resulting from an organization's activities, products or services.
5	Environmental Management System	The part or the overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environment policy.
6	Environmental Objective	Overall environmental goal, arising from the environmental policy, that an organization sets itself to achieve, and which is quantified where practicable.
7	Environmental Performance	Results of an organization's management of its environmental aspects.
8	Environmental Performance Criterion	Environmental objective, target, or other intended level of environmental performance set by the management of the organization.
9	Environmental Performance Evaluation (EPE)	Process to select environmental indicators and to measure, analyze, assess, report and communicate an organization's environment performance against its environmental performance criteria.
10	Environmental Performance Indicator (EPI)	Specific expression that provides information about an organization'senvironmentalperformance.
11	Environmental Policy	Statement by the organization of its intentions and principles in relation to its overall environmental performance which provides a framework for action and for the setting of its environmental objectives and targets.
12	Environmental Target	Detailed performance requirement, quantified where practicable, applicable to the organization or parts thereof, that arises from the environmental objectives and that needs to be set and met in order to achieve those objectives.
13	Interested Party	Individual or group concerned with or affected by the environmental performance of an organization.
14	Organization	Company, corporation, firm, enterprise, authority or institution, or part of combination thereof, whether incorporated or not, public or private, that has its own functions and administration.

(Source: ISO/DIS 14031, 1998)

9 LIFE CYCLE ASSESSMENT

MUHAMAD AWANG
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ZULINA ZAKARIA

INTRODUCTION

A good society has three closely related economic requirements, each of which is of independent force. These requirements are: the need to supply the requisite consumer goods and services; the need to ensure that this production and its use and consumption do not have adverse effects on the well-being of the public at large; and the need to ensure that they do not adversely affect the lives and well-being of future generations. The last two of these three requirements which are in frequent conflict with the first are often referred to as "the effect on the environment". The heightened awareness and concern over the environmental impacts associated with the provision of goods and services to society has led to renewed interest in the development and application of methods to better comprehend and reduce negative consequences of human activities on the environment (Galbraith, 1993).

Evidently, worldwide economic and political events over the last decade have hastened change in the business environment. This is characterized by intense worldwide competition, pressure to reduce costs and increased need for manufacturing flexibility, shortened product development cycles, improved quality and technological advancement. These pressures have, predictably, caused firms to seek sustainable advantages in all aspects of business such as changing the forms of measurements to a proactive strategy for competitive advantage through waste minimization, pollution prevention and labeling (Awang and Hassan, 1998).

Huang and Hunkeler (1997) pointed out that recently, industries are more aware and responsive to consumers' demands and expectations and are developing and utilizing technologies to manufacture environmentally 'friendly' products. Research and experience have shown that industry cannot continue merely to treat the symptoms of environmental problems. Instead, a more comprehensive means to reduce pollution is believed by many to be through prevention, by attacking the source of pollution at every stage of the product life cycle including raw material extraction, transportation, manufacturing, product use, recycling and disposal. Corporate environmental strategies have also evolved to include decision-making tools such as life-cycle analysis (LCA), design for environment (DFE), and environmentally conscious design and manufacturing (ECDM).

WHAT IS LIFE CYCLE ASSESSMENT (LCA)?

LCA is an evolving tool which can assist in management decision-making processes to reduce environmental burdens from industrial activity. It is a holistic approach for evaluating the environmental applications of products and processes from 'cradle to grave'. It provides industry with a means for identifying and evaluating opportunities to minimize adverse environmental impacts. Figure 1 provides the stages of a product life cycle, beginning with raw material acquisition, through the manufacturing process, transportation and distribution, product use and reuse, and, finally, recycling and/or disposal (CSA, 1994a:6 after Mitchell, (1997).

Life Cycle Assessment methodology is being standardized by scientific organizations such as SETAC, by individual countries, including France and the United States and presently by ISO (TC 207 SC5). The SETAC 'Code of Practice' defines life cycle assessment as follows:

> "Life cycle assessment is a process to evaluate the environmental burdens associated with a product, process or activity by identifying and quantifying energy and materials used and wastes released to the environment, to assess the impact of those energy and materials used and released to the environment, and to identify and evaluate opportunities to effect environmental improvements. The assessment includes the entire life cycle of the product, process or activity, encompassing extracting and processing raw materials; manufacturing, transportation and distribution; use, reuse, maintenance, recycling and final disposal".

The definition underlines that LCA

1. places the function of the product centrally where the service delivered by the product is the starting point; relates all environmental impacts to the function or functions analyzed,
2. includes all stages of the product's life cycle, which together form the product system,
3. is a comprehensive tool which aims to analyze all relevant environmental impacts during the entire life cycle of the product,
4. falls within a modeling approach of the product system by employing formalized analysis and using well developed mathematical software,
5. is primarily a quantitative analysis,
6. is a scientific tool which aims to be as objective and transparent as possible, and
7. must follow a strict procedure to ensure the quality of the study. This procedure includes the reliability, accuracy, source verification and representativeness of the data, as well as the sound application of the principles of LCA.

By identifying the sources of pollution throughout a product's life cycle from conception to disposal, one can determine the opportunities for minimizing environmental damage. It is important to note that LCA does not attempt to be the single solution to all environmental problems. It is being developed as a management and design tool to help guide environmentally preferable practices.

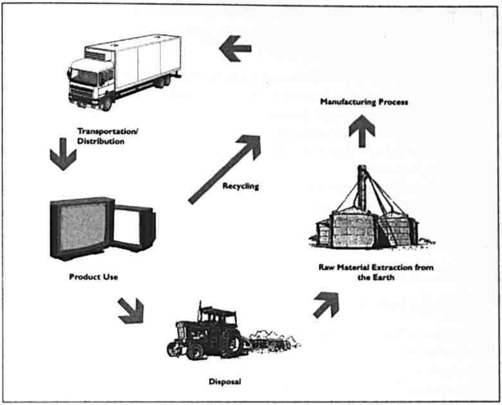

Figure 1: Life Cycle Stages (Source: Moving Ahead with ISO 14000. 1997)

THE NEED FOR LIFE CYCLE ASSESSMENT

Life Cycle Assessment was developed to meet the specific needs of organizations trying to embrace the protection of the environment in developing and improving their products, processes or activities. The main challenges are as follows:

1. The need for a systematic methodology for identifying environmental aspects of a product system to determine areas for improvement and to highlight potential trade-offs
2. The need for a better accounting, even through relatively poor economic conditions, showing that companies realize that factors leading to product success are not only service, quality and cost, but also environmental acceptability
3. The need to incorporate costs, including the cost of resources to produce the products, the cost of transformation, reflecting the environmental impacts associated with transformation i.e. releases to land, air and water, and finally the cost of disposal which reflects the societal costs of dealing with a product once it reaches the end of its useful life
4. The need to go beyond conventional approaches to pollution control to gain better returns on environmental expenditures by taking a preventive approach thus increasing opportunity for environmental and economic returns.

LCA also provides the mechanism for measuring the criteria or indicators that will demonstrate the environmental performance or acceptability of a product to the customer. Basically, LCA will provide the following:

1. Comprehensive baseline information on a system's overall resource requirements, energy consumption, and emission loading for further analysis
2. A true picture of the overall process whereby the greatest reduction in resource requirements and emissions might be achieved
3. A comparison between system input and output associated with alternative products, processes or activities
4. Guidance in developing new products, processes or activities toward a nett reduction of resource requirements and emissions
5. Assistance in identifying needs for the Life Cycle Impact Analysis
6. Information needed to conduct an improvement analysis

For application, LCA can be used by users' groups as follows:

1. For the private sector, it can assist in internal evaluation and decision making process to
   - compare alternative materials, products, processes, or activities within the organization,
   - compare resources use and release inventory information from other manufacturers,
   - use in training personnel associated with environmental management, and
   - provide baseline information needed to carry out other components of the environmental management.

2. Private sector can use LCA in external evaluation and decision making in processes to
   - provide information to policy makers, professional organizations and the general public on resources use and releases, and
   - help substantiate product statements of quantifiable reductions in energy, raw materials and environmental releases.

3. For the public sector, LCA can assist them in evaluation and policy making by
   - supplying information for evaluating existing and prospective policies affecting resources use and releases,
   - developing policies on materials and resources use and environmental releases when the inventory is supplemented with impact assessment,
   - identifying gaps in information and knowledge to help establish research priorities and monitoring requirements, and
   - helping to evaluate product statements of quantifiable reductions in energy, raw materials and environmental releases.

STAGES IN LIFE CYCLE ANALYSIS

Figure 2 provides an outline of LCA phases that could be summarized as follows (Mitchel, 1997):

Initiation

This stage is very similar to scoping in impact assessment. The main purposes are to establish the objectives for and details of an assessment, to define the "system" to be assessed, and to identify types of data needed.

Inventory Analysis

In inventory analysis primary attention is given to collecting data about raw materials needed for inputs, including energy and water, and about wastes produced as outputs during the process and at the end of the useful life of the product, process, package or related activity.

Impact Assessment

This component is similar to the comparable phase in impact assessment. The focus here is upon identifying the effects, and reaching a judgement about the significance of such effects. Effects on the environment, economy, and health or well-being are usually included.

Improvement Assessment

This can be characterized as the normative or prescriptive stage, in which attention is directed to possible actions to reduce or mitigate any negative impacts identified in the previous stage.

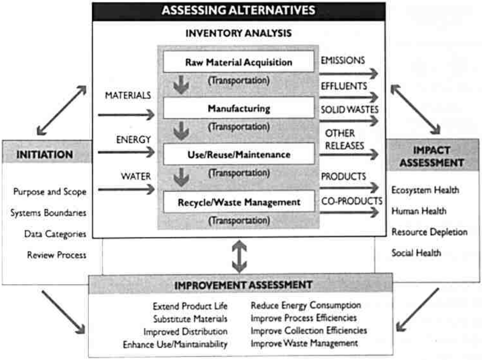

Figure 2: LCA Phases (CSA, 1994a: 13)

The four phases or components identified above and in Figure 2 are intended to assist resource and environmental managers to encourage better product design, more effective processes regarding raw material inputs or waste outputs, improved transportation methods, more careful consumer use, and better waste disposal practices.

More specifically, in the context of resource and environmental management, LCA is intended to lead to decisions which result in greater conservation of resources and the environment, increased energy conservation and decreased waste generation, improved industrial processes related to providing resource-based products, and fewer problems in final disposal.

LCA AND ITS COMPONENTS

Figure 3 illustrates the phases covered in an LCA. The study includes goal and scope definition, inventory analysis, impact assessment and interpretation of the results.

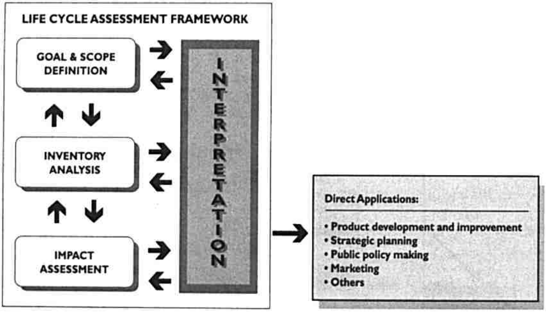

Figure 3: Phases of an LCA

Goal and Scope Definition

The goal and scope definition phase establishes

1. the purpose and scope of the study,
2. the functional unit as a central measure of the service delivered,
3. the main delineation of the product system boundaries,
4. the level of detail required by the aim of the study, setting criteria for eco-labeling, and
5. a procedure for ensuring the quality of the study.

Definition of the boundaries of the product system are of critical importance. It influences both the quantitative outcome of the analysis and the selection of categories which are to be regarded as loadings or stressors to the environment. Annex I describes in more detail the requirements for defining goal and scope.

Inventory Analysis

The inventory analysis identifies and, where possible, quantifies the inputs from the environment and the outputs to the environment of the product system under analysis. Its core result is often called an inventory table.

The inventory starts with drawing a flow chart, the process tree, incorporating all relevant processes and steps in the system defined. Some overlap with other product systems is unavoidable, because many processes are multiple ones; in other words, they have inputs or outputs in common with other product systems. Obvious examples are co-production, combined waste treatment and recycling. Here an allocation procedure has to be followed.

Data gathering is a core issue in this LCA phase. A particularly important question is how to handle data relating to generic utilities and services such as electricity, transportation and production of basis materials. As a guiding principle, a distinction has to be made between 'foreground' and 'background' data. Foreground data are related specifically to the product system in question; they should be as real as possible, based for instance on actual plant conditions and on-site measurements, if at all possible. Background data are not specifically related to the product system and may consist of average or ranges. In principle, background data on services and utilities should be extracted from the relevant market. Some technical aspects of inventory analysis are provided in Annex II.

Impact Assessment

Impact assessment characterizes and assess the effects on the environment of the loadings identified in the previous LCA phase, the inventory analysis. According to SETAC 'Code of Practice', the impact categories include the following:

1. Resource depletion - depletion of abiotic resources; depletion of biotic resources
2. Pollution - global warming; ozone depletion; human toxicity; ecotoxicity; photochemical oxidant formation; acidification; eutrophication
3. Degradation of ecosystems and landscape - land use

Essentially, the impact assessment comprises three consecutive elements, namely, classification, characterization and valuation.

Classification is the step in which the relevant impact categories, i.e. environmental problem areas, are identified and where the loadings are assigned to each problem area which SETAC has drawn up a basic list of impact categories. Environmental problem types can be ranked on the basis of their geographical scale, from global (climate change) to local (noise, occupational health). Most impact categories relate to regional or global levels and not to the local level. In general, this list can be extended; however, extension depends on the type of product system in question.

Characterization is the element in which the effects of the loadings are specified and where possible are quantified and aggregated into a small number of selected types of impact. SETAC identifies different approaches for quantification of the impacts, with varying levels of detail and formalization. The approach based on the use of equivalency factors seems the most appropriate as far as life cycle assessment is concerned. These have only been developed for a few impact categories. For the others, some are being developed and for the renewing impact categories nothing similar exists. Impacts might have their cause-effect chains at a global, regional or local level.

In the characterization element, the assessed impacts within the different impact categories may be normalized into an additional element. This can be done by calculating the assessed impacts as fractions of the total anthropogenic contribution to the various impact categories in a given year in a given area. The core results of the characterization are often referred to as the impact profile or the normalized impact profile, if the calculating method described above has been applied.

Valuation is a normative element based on social values which by their nature cannot be defined purely in the framework of natural science. In this element the different impact categories are weighed against each other. The aim is to obtain an overall environmental comparison of the available alternatives. In the ISO process, it is not yet clear whether valuation will remain a part of impact assessment or become part of the interpretation.

This valuation element may follow a structured weighting procedure or it may be performed on an *ad hoc* basis. There are techniques which indicate the revealed preferences of governments towards environmental management, for instance, techniques based on policy priorities, stated environmental targets or critical loads and on policy induced costs for different types of environmental improvements. Clearly the weights in these procedures cannot be based solely on natural science.

Interpretation

The last LCA phase of the ISO framework concerns interpretation. Here the results of the preceding LCA phases are compared with the goal of the study set in the goal and scope definition. The structure of this phase is still in development. One crucial element concerns validation of the results.

Validation

Two approaches can be used, which complement each other:

1. Performance of sensitivity analyses by the LCA practitioners involved
2. Independent, external review. Such an external review is often called a peer review.

Improvement Assessment

Another element may be the improvement assessment in which options for reducing the environmental impacts of the system(s) under study are identified and evaluated. This is performed on the basis of results from the previous LCA phases.

The steps for carrying out the improvement assessment are

1. load analysis, indicating relevant processes,
2. identification of improvement options, and
3. ranking and selection of the options available based on their effectiveness and on external variables such as feasibility.

Feasibility includes consumer preference and economic aspects and implies a need for data taken from outside the scope of the life cycle assessment.

Iterative Character

The LCA phases and the elements within them as described above do not themselves constitute the LCA procedure. The LCA procedure is an iterative process, running through the different LCA phases and their elements, increasing the level of detail and thus reliability of the process at each iteration. This might be a selective process. The level of detail is increased in areas which appear to be key issues for further analysis. Annex III lists a series of questions which could assist in conducting an LCA. The process of selecting key issues is sometimes referred to as screening. It has to be carried out with special attention. Errors might slip in if issues are omitted without adequate justification.

LCA may not always be the most appropriate technique to use in all situations. LCA typically does not address the economic, technical or social aspects of a product and among the limitations that have been identified are as follows:

1. The nature of choices and assumptions made in the LCA procedure (e.g. boundary setting, selection of data sources and impact categories) may be subjective in some applications.
2. Models used for inventory analysis or to assess environmental impacts are limited by their assumptions, and may not be available for all potential impacts or applications.
3. Results of an LCA focused on global and regional issues may not be appropriate for local applications (i.e. local conditions might not be adequately represented by regional or global conditions).
4. The accuracy of LCA results may be limited by accessibility or availability of relevant data, or by data quality (e.g. gaps, types of data, aggregation, average vs. industry specific).
5. The lack of spatial and temporal dimensions in the inventory data used for impact assessment introduces uncertainty and limits the accuracy of impact results. This uncertainty varies with the spatial and temporal characteristics of each impact category.
6. LCA results are complex and can generally not be reduced to a single overall conclusion in a technically objective manner.

Generally, the information developed in an LCA should be used as part of a much more comprehensive decision process or used to understand the broad or general trade-offs. Comparing results of different LCAs is only possible if the assumptions and context of each study are the same. These assumptions should also be explicitly stated for reasons of transparency. Due to the complex nature of LCA studies, requirements for reporting and critical reviewing have been developed by the LCA users and practitioners. Annex IV describes these requirements in greater detail.

LIFE CYCLE ASSESSMENT PROGRAM OF WORK

LCA (ISO 14040) serves as a general framework for the methodology used. A basic requirement for LCA is that it needs to be transparent on the method and data being used. For example, in the case of multiple inputs into and outputs from distinct systems, there exist many ways of distributing flows between the relevant systems. LCA does not indicate which procedures are to be used, but makes it mandatory to declare in an open way which procedure have been used. It is an obligation to make available to the public a complete report on all of the essential aspects of the study.

This means that the results of the life cycle assessment are to be publicly produced to support any declaration suggesting that product A is better than product B from the standpoint of its impact on the environment. Therefore the standard makes it compulsory that complete external checking of the validity of claims be carried out.

Therefore the standard should be a form of guarantee for the companies which are willing to use life cycle assessment. It gives them credit for choosing a progressive action in the ecological management of their product; and also serves as a form of defense against their competition by ensuring that any public statement comparing a product with another has previously been reviewed in an open, documented and proven manner.

LCA specifies the methodological framework and gives the requirements for application of the main concepts of the analysis. It is planned that LCA gives requirements and recommendations for completing the various phases of a life cycle, from a technical to standpoint. Refer to Figure 3 for the LCA framework.

Life Cycle Inventory Analysis: ISO 14041

The first of these more technical standards will be a method for conducting an inventory; it will cover the first two phases of any life cycle assessment:

The Definition of the Objective and Scope of the Study

This phase is essential for checking the validity of the rest of the assessment, the magnitude and depth of which, and hence the costs, will depend on the client's requirements as to the type of decisions under examination.

It is easy to imagine that a life cycle assessment whose intention is to define a national or regional policy for waste recycling or treatment will have to be based on a huge quantity of data. It will be very different in scope from the study performed by a company wanting to optimize the volume, power input and construction materials of an electrical appliance.

As a consequence, life cycle assessment is dependent on its objective. The transparency requirement is essential; the client requesting the study will have to openly declare to the one who will carry out the assessment what his true intention is. In the latter example, it is easy to see that if the company does not inform the one who carries out the study that its intention is to use the results for comparative marketing in the competitive field, there will be problems. The consequences resulting from the lack of a clear view of the objectives in some of first experiences of life cycle assessment justify that very close attention be paid to that particular phase of the assessment in the future ISO 14041.

Inventory Analysis

ISO 14041 will specify technical requirements and recommendations for that phase which rules the issues to be addressed including what is to be adopted for deciding that a flow is depreciated; how to allocate flows between various functions; how to deal with the products, the various types of recycling, etc.

Life Cycle Impact Assessment: ISO 14042

An explanation is needed at this stage to justify the completion of the technique, i.e. potential impact assessment. The concept of "potential" has a very precise meaning. It represents an approximation of the real impact which is maximized for precaution. The reason is that the exact relationship between the flows and the real impact cannot be modeled at a finer level of detail. It cannot reflect 100% of the scatter effects in time or space, nor the effects of the threshold below which a flow has a zero effect. The potentiality here represents the inherent capability of causing damage (hazard), as well as the probability of the damage (risk).

Life Cycle Interpretation: ISO 14043

The development of a standard for interpretation of results does not correspond to the solution of technical problems. Its objective is to show the links which may exist between life cycle assessment and other techniques of environmental management, and to explain the limits of LCA professionals' responsibilities in relation to the use that is made of their studies.

LIFE CYCLE ASSESSMENT - A COMPONENT OF ISO 14000 SERIES

Life Cycle Assessment (LCA) is a one of the components of the ISO 14000 series of standards. In Figure 4, LCA falls under the category of product evaluation, i.e. in the same category as Environmental Labeling (EL) and Environmental Aspects in Product Standard (EAPS). As a component of the system, LCA is very useful in providing a detailed analysis on process, product or activity to the requirement of Environmental Labeling, Environmental Management System (EMS), Environmental Audit (EA), and Environmental Performance Evaluation (EPE). LCA provides the clear picture and the process flow of a product, activity, or process from cradle to grave. This input will be used in application of other environmental management evaluations such as EMS, EL, EA or EPE. For example, in order to conduct EL, one of the data required is the process flow of a product. The Life Cycle Inventory of LCA will detail such a requirement.

Before any organization can embark on EMS, EL, EA or EPE, there is a need for LCA, to help provide the details of process, product or activity. Subsequently, the data provided by LCA is to be made available for peer and public review. These characteristics of an LCA are that it be scientifically based, quantitative, appropriately detailed, replicable, comprehensive, consistent, peer reviewed and useful. These characteristics help to instill confidence in and acceptance by the customer or public of the product, process or activity.

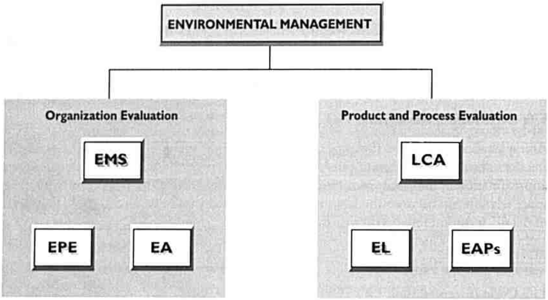

Figure 4: Conceptual Linkage of ISO 14000

RELATIONSHIP BETWEEN LCA AND OTHER MANAGEMENT TOOLS

The standards in the ISO 14000 series are developed as separate documents, so that the users are not driven to specific approaches outside their policy and objectives. However, there exist potential relationships between the components that make up the standards. In particular, ISO 14001 specifies that "The organization identifies the environmental aspects of its activities, products or services that it can control, in order to determine those which have or can have significant impacts on the environment. The organization shall ensure that the aspects related to these significant impacts are considered in setting its environmental objectives".

It is therefore obvious that the organization may consider using LCA for the purpose of identifying the environmental aspects of its product or services. LCAs are useful in almost all the structures that make up the ISO 14001. Further to that, the relationship between the tools could be summarized as described in Figure 5.

Indicators developed for Environmental Performance Evaluation (EPE) may address various environmental aspects of the product, depending on the scope set for the evaluation. If

EPE is limited to a specific site, indicators may be developed for EPE on the basis of techniques similar to life cycle assessment as far as balances and circulation sheets are concerned. However, such approaches necessarily drop the fundamental concept of cradle-to-grave and therefore should not be called Life Cycle Assessment but rather process mapping. But, for a whole organization, a tool for evaluating environmental aspects with regard to a product or service system, Life Cycle Assessment is used to provide the indicators. This means that LCA information can be used to support a whole range of management functions. The data can be used when developing a comprehensive inventory, or when a company needs to rationalize a large portion of their environmental information into one data set. There are many different uses of inventory data, depending upon the kind of actual or potential impacts considered. For actual impacts, it can be used for site assessment, risk assessment, environmental management system analysis, initial review, environmental performance evaluation, bench marking, pollution prevention, eco-efficiency and sustainability index. For potential impacts, it can be used in product strategy development,

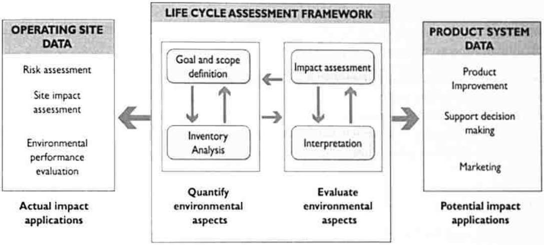

Figure 5: Life Cycle Assessment and Relationships (Showing Actual Impact Application and Potential Impact Applications)

design for the environment and material selection, public policy, product stewardship, marketing, environmental claims, eco-labeling, sustainable consumption and production.

SUMMARY

The phases of an LCA are (1) establishing goals and the scope of the assessment, (2) inventory analysis, (3) the impact assessment, and (4) improvement assessment. Impact assessment has three elements: classification, characterization, and valuation. The goals of the LCA study should include the reasons for carrying out the study, the intended applications, the intended audience, the initial data quality objectives, and the type of critical review that will be conducted for the LCA. The scope should include background information for the product or service being evaluated, boundaries of the study, method of impact assessment, data requirements, assumptions, and limitations of the study.

The standard recognizes that there is no single method to conduct LCAs, and it allows organizations flexibility in implementing the LCA. The assessment can be suited to the particular product or services, but it is important for the assessment to be systematic, understandable, and transparent. The methodology should be based on current scientific findings and improvements in LCA. The results should not be reduced to a simple overall conclusion, but they should reflect the complexities and trade-off inherent in the process. The assessment must respect confidentiality and proprietary matters. The results of the LCA must be reported to the intended audience and to interested third parties. The report should cover the goals and scope of the study, the methods employed, the results (and critical elements), and conclusions and recommendations.

Although LCAs can provide useful information for decision making, the assessment process does have limitations, and it may not be appropriate in all situations. Parties using LCAs should recognize that the assessment methodology is still developing and that the outputs are only as good as the inputs and method of assessment. In some instances, the data may not be available to conduct a complete assessment, economic and social issues may not be addressed, or the data may not be appropriate for the circumstances (for example, a focus on global impacts may not be appropriate for a localized project).

Some of the potential problems with LCAs can be minimized by the critical review recommended by the standard. The intention of the critical review is to ensure that the study was conducted according to the requirements of the LCA standard and to ensure the validity of the results. The review can be conducted in several ways, and it might include self-review, expert or practitioner review, or peer and stakeholder review.

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ANNEX I: GOAL AND SCOPE DEFINITION

Before initiating or commissioning an LCA, the goal and scope of the study shall be clearly defined. These shall be consistent with the intended application.

Goal of the Study

The goal of a specific LCA study shall state the reasons for carrying out the study, the intended applications and the intended audience.

Scope of the Study

In defining the scope of a specific LCA, the following items shall be considered and should be clearly described: the function of the system; the functional unit; the system to be studied; the system boundaries; the extent and type of impact assessment to be used, if any; data requirements; assumptions; limitations; the initial data quality requirements; the type of critical review, if necessary; and the type and format of the report required for the study.

The scope should be sufficiently well defined to ensure that the breadth, the depth and the detail of the study are compatible with and sufficient to address the stated goal, and all boundaries, methodologies, data categories, and assumptions are clearly stated, comprehensible, and transparent. As LCA is an iterative technique, the scope of the study may need to be modified while the study is being conducted as additional information is collected.

Considerations for Goal and Scope Definition

Function and Functional Unit

An important consideration in defining the scope of an LCA study is a clear specification of the functions that are performed by the system being studied. Derived from that specification, the functional unit is a measure of the functional output of the system being studied. One of the primary purposes for the functional unit is to ensure comparability of LCA data by using a common unit measure of system function. Comparability of LCA data is particularly critical when different systems are being assessed to ensure that such comparisons are made on a common basis. Examples of functional units are the amount of packaging used to deliver a specific volume of a beverage, or the amount of detergent necessary for a standard household wash. A system may have a number of possible functional units and the one selected for a study is dependent on the goals and scope of the study. The functional unit shall be defined, measurable and relevant to input and output data.

Systems and System Boundaries

A system is a series of unit processes, connected by material or energy flows, which performs one or more defined functions. The system boundaries determine which operations, inputs and outputs will be included within the LCA. Several factors enter into the determination of system boundaries, including the intended application of the study, the assumptions made, data and cost constraints, and the intended audience. In defining the inputs and outputs, the level of aggregation within a data category shall be consistent with the goal of the study. The system should be modeled in such a manner that inputs and outputs at its boundaries are elementary flows. The criteria used in establishing the system boundaries should be identified and justified in the scope phase of the study. LCA studies used to make a comparative assertion that is disclosed to the public shall perform an analysis of material flows to determine their inclusion in the scope of the study.

Data Quality Requirements

Data quality is the degree of confidence in individual input data from a source, aggregated data and in the data set as a whole. LCA data quality is described by establishing data quality indicators for the study. Data quality goals specify in general terms the desirable characteristics of the data needed for the study. The data quality requirements shall be defined to enable the goals and scope of the LCA study to be met. The data quality requirements should address issues such as the precision, completeness, and representativeness of the data and the data sources; the consistency and reproducibility of the methods used throughout the LCA; the sources of the data; and the variability and uncertainty of the information and methods. LCA studies shall, at a minimum for comparative assertions, assess the precision, completeness, and representativeness of the data, as well as the consistency and reproducibility of the methods used throughout the LCA.

Comparisons Between Systems

In comparative studies, systems shall be compared using the same functional unit. If the performance of the systems or the various functions of the systems are not identical and not taken into account in the functional unit, the differences shall be identified. The equivalence of the systems should be evaluated before interpreting the results. This evaluation shall include all sensitive methodological choices of the study (e.g. functional unit, system boundaries, allocation rules).

ANNEX II : SOME TECHNICAL ASPECTS OF LIFE CYCLE INVENTORY ANALYSIS

Steps of performing a life cycle inventory are as follows:

1. Define the purpose and scope of the inventory
2. Define the system boundaries
3. Institute a peer review process
4. Gather data
5. Develop stand-alone data
6. Construct a computational model
7. Present the results
8. Interpret and communicate the results

In defining the purpose and scope of the inventory, the decision to perform a life cycle inventory is usually based on one or several of the following objectives:

1. To establish a baseline of information on a system's overall resource use, energy consumption, and environmental loadings
2. To identify stages within the life cycle of a product or process where a reduction in resource use and emissions might be achieved
3. To compare the system inputs and outputs associated with alternative products, processes, or activities
4. To help guide the development of new products, processes, or activities toward a nett reduction of resource requirements and emissions
5. To help identify areas to be addressed during life cycle impact analysis

A life cycle inventory can be envisioned as a set of linked activities that describe the creation, use, and ultimate disposition of the product or material of interest.

Life cycle inventories can have a mix of product-specific and industry-average information. For instance, the alternative decision path, using industrial average data for making recycled paperboard, had a parallel mix of advantages and limitations. Use of average, or generic, data may be advantageous for a manufacturer considering use of recycled board for which no current vendors have been identified. The limitation is that data from this stage may be less comparable to that of more product-specific stages that mix product-specific and more general analyses in the same life cycle stage. It is recommended that the level of specificity be very clearly defined and communicated so that readers are more able to understand differences in the final results.

Systems and System Boundaries

In defining the system, the first step is to set the system boundaries. A complete life cycle inventory will set the boundaries of the total system broadly to quantify resource and energy use and environmental releases throughout the entire life cycle of a product or process as shown in (Figure A1). As illustrated, this model combines materials manufacture, product fabrication, and filling/packaging/distribution in the manufacturing stage. Separating these three aspects of manufacturing into substages, or steps, reflects the fact that different organizations are typically involved in these activities. The separate treatment also reflects the different nature of the operations and the decisions discussed earlier regarding product, material, or activity specificity. Recycling and waste management are combined into one stage, especially for post-consumer material recycling and waste management. This simply represents a splitting of the material flow between the two streams. A life cycle, therefore, comprises four major stages (distribution and transportation stages are included as part of the manufacturing stage).

Raw Materials Acquisition Stage

All the activities are required to gather or obtain a raw material or energy source from the earth. This stage includes transportation of the raw material to the point of material manufacture, but does not include material processing activities.

The Manufacturing Stage

The manufacturing stage encompasses three steps:

Materials manufacture. The activities required to process a raw material into a form that can be used to fabricate a particular product or package. Normally, the production of many intermediate chemicals or materials is included in this category. Transport of intermediate materials is also included.

Product fabrication. The process step that uses raw or manufactured materials to fabricate a product ready to be filled or packaged. This step often involves a consumer product that will be distributed for retail sales, but the product could also be distributed for use by other industries.

Filling/packaging/distribution. Processes that prepare the final products for shipment and that transport the products to retail outlets. Although these activities may commonly require a change in the location or physical configuration of a product, they do not involve a transformation of materials.

Use/Reuse/Maintenance Stage

Begins after the product, package, or material has served its intended purpose and either will enter a new system through recycling or will enter the environment through the waste management system.

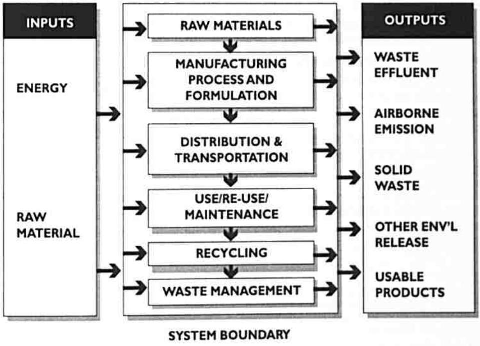

Figure A1: Life Cycle Inventory

Each step in the life cycle of a product, package, or material can be categorized within one and only one of these life cycle stages. Each step or process can be viewed as a subsystem of the total product system. Viewing the steps as subsystems facilitates data gathering for the inventory of the system as a whole. Product systems are easier to define if the sequence of operations associated with a product or material is broken down into primary and secondary categories. The primary, or zero-order, sequence of activities directly contributes to making, using, or disposing of the product or material. The secondary category includes auxiliary materials or processes that contribute to making or doing something that in turn is in the primary activity sequence.

In setting system boundaries, the analyst must decide where the analysis will be limited and be very clear about the reasons for the decision. The following questions should be considered. Does the analysis need to cover the entire life-cycle of the product? Depending on the goal of the study, it is possible to exclude certain stages or activities and still address the issues for which the life cycle inventory is being performed.

What will be the basis for use of the product or material? If the products or processes are used at different rates, packaged in varying quantities, or come in different sizes, how can one accurately compare them? Can equivalent use ratios be developed? Should market shares be considered to estimate the proportionate burden from each product in a given category? Is the study intended to compare service systems? Are the service functions clearly defined so that the inputs and outputs are properly proportioned?

What ancillary materials or chemicals are used to make or package the products or run the processes? Resource constraints for the life cycle inventory may be considered in defining the system boundaries, but in no case should the scientific basis of the study be compromised. The level of detail required to perform a thorough inventory depends on the size of the system and the purpose of the study. In a large system encompassing several industries, certain details may not be significant contributors given the defined intent of the study. These details may be omitted without affecting the accuracy or application of the results. However, if the study has a very specific focus, such as a manufacturer comparing alternative processes or materials for inks used on packaging, it would be important to include chemicals used in very small amounts. Additional areas to consider in setting boundaries include the manufacture of capital equipment, energy and emissions associated with personnel requirements, and pre-combustion impacts for fuel usage.

Often in studies intended for external application, the system flow diagram is incorporated into a format scope, boundary, and data collection (SBDC) document. The SBDC document provides the basis for peer reviewers and others to understand how the analyst is defining the study and how these definitions and assumptions will translate into data collection activities.

Devising an Inventory Checklist

The inventory checklist is a tool that covers most decision areas in the performance of an inventory. After the inventory purpose and boundaries have been defined, a checklist can be prepared to guide data collection and validation and to enable construction of the computational model.

Although this checklist is an effective guidance tool and enhances transparency, it is not the sole quality control process under which the analysis should be performed. Eight general decision areas should be addressed on the checklist or worksheet:

1. The purpose of the inventory
2. System boundaries
3. Geographic scope
4. Types of data used
5. Data collection and synthesis procedures
6. Data quality measures
7. Computational model construction
8. Presentation of the results

The checklist can also help clarify the issues, boundaries, and conditions to be dealt with in a particular study. Worksheets can be used by the analyst to collect and qualify data from facilities. The checklist consists of two major components - a summary section describing the procedures and systems included in the study and a set of worksheets listing and qualifying the data collected. In a life cycle inventory where there may be many steps in each life cycle stage, the worksheets help ensure consistency among the various information sources. Modules consisting of subsystem inputs and outputs are the basis for preparing a life cycle inventory. Subsystem modules represent fundamental operations that are building blocks for aggregating data into the life cycle stage and the overall system level. By including a completed checklist in the report on the results of an inventory, the analyst can communicate to readers some of the factors that may affect the results. The checklist will help readers gain knowledge and understanding of the system's boundaries, data quality, methodology used, and level of detail. The standard checklist also can be of use to peer reviewers as it provides useful criteria and information to assure the completeness of a particular life cycle inventory.

Peer Review Process

Overall, a peer review process should address the scope/boundaries methodology, data acquisition/compilation, validity of key assumptions and results, and communication of results. The peer review panel could participate at several points in the study including

1. reviewing the purpose, system boundaries, assumptions, and data collection approach,
2. reviewing the compiled data and the associated quality measures, and
3. reviewing the draft inventory report, including the intended communication strategy.

It is generally believed that the peer review panel should consist of a diverse group of 3 to 5 individuals representing various sectors, such as federal, state, and local governments, academia, industry, environmental or consumer groups, and LCA practitioners. The credentials or background of individuals should include a reputation for objectivity, experience with the technical framework or conduct of life cycle studies, and a willingness to work as part of a team. The issue of how the reviews should be performed raises a number of questions, such as these: Should a standard checklist be required? Should oral as well as written comments from the reviewers be accepted? How much time should be allotted for review? Who pays for the review process?

The peer review process should be flexible to accommodate variations in the application or scope of life cycle studies. Peer review should improve the conduct of these studies, increase the understanding of the results, and aid in further identifying and subsequently reducing any environmental consequences of products or materials.

Data Gathering

For data-gathering purposes it is appropriate to view the system as a series of subsystems. A "subsystem" is defined as an individual step or process that is part of the defined production system. Some steps in the system may need to be grouped into a subsystem due to lack of specific data for the individual steps. Each subsystem requires inputs relating to materials and energy, and transportation of the product produced, and has outputs of products, co-products, atmospheric emissions, waterborne wastes, solid wastes, and possibly other releases. Data should be gathered for the amounts and kinds of material inputs and the types and quantities of energy inputs. The environmental releases to air, water, and land should be quantified by type of pollutant. Data collected for an inventory should always be associated with a quality measure.

Sources of data

1. Electronic non-bibliographic data bases (government and industrial):
   - Averaged industrial data
   - Product specifications
2. Electronic bibliographic data bases
3. Electronic database clearinghouses
4. Relevant documents:
   - Government reports
   - Open literature papers and books
   - Other life cycle inventories
5. Facility-specific industrial data:
   - Publicly accessible
   - Non-publicly accessible
6. Laboratory test data
7. Study-specific data

A number of sources should be used in collecting data. Whenever possible, it is best to get well-characterized industry data for production processes. Several categories of data are often used in inventories. These categories include:

1. Individual process — and facility-specific — data from a particular operation within a given facility that are not combined in any way
2. Composite data from the same operation or activity combined across locations

3. Aggregated- data combining more than one process operation
4. Industry-average — data derived from a representative sample of locations and believed to statistically describe the typical operation across technologies
5. Generic — data whose representativeness may be unknown but which are qualitatively descriptive of a process or technology

Lack of technically sound data adversely affects the credibility of both the life cycle inventories and the method for performing them. An individual company's trade secrets and competitive technologies must be protected. Some form of selective confidentiality agreements for entities performing life cycle inventories, as well as formalization of peer review procedures, is often necessary for inventories that will be used in a public forum.

Data Processing

Stand-alone Data

'Stand-alone data" is a term used to describe the set of information developed to standardize or normalize the individual subsystem module inputs and outputs for the specific product, process, or activity being analyzed. Stand-alone data must be developed for each subsystem to fit the sub-systems into a single system. There are two goals to achieve in this step: (1) presenting data for each subsystem consistently by reporting the same product output from each subsystem and (2) developing the data in terms of the life cycle of only the product being examined in the inventory. First, a standard unit of output must be determined for each subsystem. All data could be reported in terms of the production of a certain number of pounds, kilograms, or tons of subsystem product.

Computational Model

This step consists of incorporating the normalized data and material flows into a computational framework using a computer spreadsheet or other accounting technique. The systems accounting data that result from the computations of the model give the total results for the energy and resource use and environmental releases from the overall system. The overall system flow diagram, derived in the previous step, is important in constructing the computational model because it numerically defines the relationships of the individual subsystems to each other in the production of the final product. These numerical relationships become the source of "proportionality factors", which are quantitative relationships that reflect the relative contributions of the subsystems to the total system. It is important that each subsystem be incorporated in the model with its related components and that each be linked together in such a way that inadvertent omissions and double-counting do not occur. The computer spreadsheet can be organized in several different ways to accomplish this purpose.

Presentation of the Inventory Results

The report should explicitly define the systems analyzed and the boundaries that were set. All assumptions made in performing the inventory should be clearly explained. The basis for comparison among systems should be given, and any equivalent usage ratios that were used should be explained.

It is useful to identify the various perspectives embodied in life cycle inventory information. These dimensions include but may not be limited to the following:

1. Overall product system
2. Relative contribution of stages to the overall system
3. Relative contribution of product components to the overall system
4. Data categories within and across stages, e.g. resource use, energy consumption, and environmental releases
5. Data parameter groups within a category, e.g. air emissions, waterborne wastes, and solid waste types
6. Data parameters within a group, e.g. sulfur oxides, carbon dioxide, chlorine, etc.
7. Geographic regionalization if relevant to the study, e.g. national *versus* global
8. Temporal changes

The life cycle analyst must select among these dimensions and develop a presentation format that increases comprehension of the findings without oversimplifying them.

Interpretation and Communication of Inventory Results

How the results of the life cycle inventory will be interpreted depends on the purpose for which the analysis was performed. An important criterion in understanding or interpreting the results is data accuracy. Before publishing any statements regarding the results of the analysis, it is important to review how the assumptions and boundaries of the system were defined, the quality level of the data used, and the specificity. Careful interpretation is required to avoid making unsupported statements. The analyst should interpret the importance of these sources of variability for the reader. For life cycle inventories, a sensitivity analysis would evaluate how large the uncertainty in the input data can be before the results of the inventory can no longer be used for the intended purpose.

The boundaries and data for many internal life cycle assessments may require the interpretation of the results for use within a particular corporation. Life cycle inventory information may be provided to consumers to support statements about certain features or specific reduction claims. The analyst must be careful to provide an interpretative context and not selectively use information. The results of externally published studies comparing products, practices, or materials should be presented cautiously, and assumptions, boundaries, and data quality should be considered in drawing and presenting conclusions. Studies with different boundary conditions may have different results, yet both may be accurate. These limitations should be communicated to the public along with all the results; it is misleading to selectively report inventory results.

ANNEX III : CHECK-LIST OF CRITICAL ASPECTS OF AN LCA

1. Are the reasons for carrying out the study, the intended uses and the intended audience clearly and unambiguously identified?
2. Are the functions of the systems being studied clearly identified? If the study is

comparative, are the functions of the systems equivalent? If not, are the reasons for the differences appropriately treated?

4. Is the functional unit appropriate for the goal of the study? Is it measurable? For comparative studies, are the functional units comparing equivalent functions?
5. Are the systems to be studied clearly described? Are the systems boundaries clearly stated?
6. Are the data categories adequately identified and is the level of specification appropriate for the goal of the study?
7. Has an analysis of material flows been performed to determine which material flows are included in the scope? For comparative studies are the cut-off material flows in the unit process and the mass contribution to the systems at equivalent percentages?
8. Are the data quality characterization procedures appropriate and reasonable?
9. Has the question of the type of critical review to be used been addressed?
10. Are the initial assumptions and limitations of the study clearly stated, reasonable and justified?
11. Is the methodology clearly identified for conducting the inventory analysis? Is it of sufficient detail for someone to follow the instructions and repeat the study?
12. Have the appropriate flow process charts, descriptions of unit processes, glossary of terms and measures been prepared? Are the data collection instructions appropriate for the data categories selected? Is there a process for reporting locations to highlight irregularities? Does the reporting location confirm the scope of the unit process and collection procedures?
13. Does the study include production and delivery energy and feedstock energy as well as process energy? Does the calculation of electrical energy include production and delivery energy, combustion efficiencies, conversion efficiencies, and transmission and distribution losses? Have environment related releases been included for energy consumption? Is there a process to identify missing data and anomalies and to determine the acceptable data inputs?
14. Where allocation procedures were used, was the input and output data relevant to any allocation procedures appropriately outlined? Was the choice of allocation method appropriately justified, consistent with the goal of the study?
15. Is the methodology for data calculations sound? Are data assumptions clear, reasonable and justified? Were inputs and outputs related to a unit process normalized to a standard measure and also normalized to the function unit in an appropriate manner?
16. Have data quality requirements been evaluated?
17. Has the methodology defined in the scope been consistently applied?
18. Are all the data sources identified?
19. How are the data aggregated? summarized? presented?
20. Is reporting objective and transparent?
21. Is the methodology adequately identified, sufficient to allow the study to be reproduced?
22. Has the purpose of the study been met?
23. Are the conclusions supported by the data and limitations identified in the analysis?
24. Is a report been prepared that is suitable as a reference document for third party communications?

25. Does the report identify who conducted the study, those who sponsored it and those who participated it?
26. Are the reasons for the study, the application of the results and the intended audience clearly and unambiguously described in the report?
27. Does the description in the report give an accurate and comprehensive outline of the systems studied, the functions performed and the functional unit selected, the boundary conditions, the decision rules for inclusion of material flows, the initial data quality requirement and the type of critical review?
28. Are the sources of data, data collection procedures, data validation processes, data aggregation and calculation procedures, and allocation procedures clearly described in the report?
29. Is the presentation of input and output data that is normalized to the functional unit outlined in a complete and comprehensive manner? Is the level of detail on the input and output data for the unit processes presented in a suitable manner?
30. Are all sensitivity analyses presented in the report which highlight the significant assumptions, decisions made on the scope and alternative allocation procedures clearly presented and referenced?
31. Is the data quality assessment complete for all data quality requirements and clearly outlined in the report?
32. Are the critical review reports and any responses attached to the report?
33. Is the report on the interpretation of the results consistent with the goal and scope of the study?
34. Are the limitations and constraints for the use of the study results clearly described in the report?
35. Was a sensitivity analysis performed to determine the energy contribution of material flows to a defined level of contribution?
36. Was a sensitivity analysis performed to analyze the environmental relevance of material flows to a defined level of contribution to all release data categories?
37. Were the equivalent cut-off levels for energy contribution and environmental relevance selected for the system modeled?
38. Was a sensitivity analysis performed using data collected during the analysis to verify the decisions made?
39. Was the data quality assessment performed on the precision, completeness, representativeness, consistency and reproducibility of the study?
40. Was an independent practitioner or expert selected to chair the review panel? What was the basis for determining the appropriate experience and expertise of the additional review panel members? Were the responses to the review panel reports appropriate to the recommendations made?

ANNEX IV: REPORTING AND CRITICAL REVIEW

LCA Reporting

General Requirements

The results of the LCA shall be fairly and accurately reported to the intended audience. The extent and detail of a report should be defined in the scope phase of the study. In particular, the report may cover

1. the goals and the intended scope of the study including the boundaries set and the methods employed,
2. the results in adequate detail,
3. assumptions and limitations,
4. critical elements of these results, identified by a sensitivity analysis for example,
5. the findings of the interpretation phase, and
6. the findings of the critical review, if performed.

The results, data, methods, assumptions and limitations should be presented in sufficient detail to allow the reader to comprehend, interpret and use the results in a manner consistent with the goals of the study.

Communication to Third Parties

A report shall be prepared before the results the LCA study are communicated, regardless of the form of the communication. This report constitutes a reference document, and shall be made available to any third party to whom the communication is made. The report shall cover:

1. General aspects that include the following: LCA commissioner, practitioner of LCA (internal or external), date of report and reference to the sections of the report where the requirements of ISO LCA standards are applied.
2. Goal and scope definition which includes goal, scope, data quality requirements and critical review, if any.
3. Life cycle inventory analysis: data collection and calculation procedures.
4. Life cycle impact assessment, the nature and extent of impact assessment that was performed.
5. Interpretation of the results, the limitations associated with the interpretation of results, both methodology and data related, data quality assessment and critical review reports and responses to recommendations, if any.

LCA CRITICAL REVIEW

General Description

The objective of the critical review process is to ensure that

1. the methods used to carry out the LCA are consistent with this International Standard, and are technically and scientifically valid,
2. the data used are appropriate and reasonable in relation to the goal of the study,
3. the interpretations are valid based on the limitations identified and the goal of the study, and
4. the study is transparent and consistent.

The International Standard does not specify requirements relating to the goals or uses of LCA, critical review can neither verify nor validate the goals that are chosen for an LCA, or the uses to which LCA results are put. The scope and type of critical review desired should be defined in the scope phase or an LCA study.

Need for Critical Review

A critical review may facilitate understanding and enhance the credibility of LCA studies, for example by involving interested parties. There is a significant potential for misuse when LCA studies are used to make a comparative assertion. This use of LCA is discouraged because it is highly unlikely that LCA studies can be sufficiently complete, representative and objective to justify such assertions. The use of LCA results to support comparative environmental assertions raises special concerns and requires critical review since this application will likely affect interested parties that are external to the LCA study. In order to decrease the likelihood of misunderstandings or negative effects on external stakeholders, critical reviews shall be conducted on LCAs where the results are used to support comparative assertions. However, the fact that a critical review has been conducted should in no way imply an endorsement of any comparative assertion that is based on an LCA study.

Critical Review Processes

If an LCA study is to be critically reviewed, the scope of the critical review should be defined in the goal and scope definition phase of the study. The scope should identify why the critical review is being undertaken, what will be covered and to what level of detail, and who needs to be involved in the process. Confidentiality agreements regarding the content of the LCA study should be entered into as needed.

Internal Review

A critical review may be carried out by the person who conducted the LCA. An internal expert may assist in the conduct of an internal review. The review statement, which is the output of the critical review process, is prepared by the person conducting the LCA study and is included in the LCA study report.

Expert Review

A critical review may also be conducted by an external, independent practitioner or expert who is familiar with the ISO LCA standards. The review statement is prepared by the person conducting the LCA study and reviewed by either the independent expert who is familiar with and can interpret the requirements of the LCA standard or by an external independent practitioner. The review statement may also be prepared in its entirety by the external practitioner. The review statement, comments of the practitioner or expert and any response to recommendations made by the reviewer are included in the LCA study report.

Review by Interested Parties

An external independent practitioner or expert is selected by the original study practitioner to act as chair of a review panel. Based on the goal, scope and budget available for the review, the chair selects other independent qualified reviewers. This panel may include other interested parties that will be affected by conclusions drawn from the LCA study, such as government agencies, non-governmental groups, or competitors. The review statement and review panel report, as well as comments of the expert or practitioner and any responses to recommendations made by the reviewer or by the panel shall be included in the LCA study report.

ANNEX V : DEFINITIONS

- **Allocation.** Technique for partitioning multiple inputs and outputs from a system.
- **Ancillary Material.** Material input that is used by the unit process producing the product, but is not used directly in the formation of the product.
- **Comparative Assertion.** Environmental claim made publicly regarding the superiority of one product *versus* a competing product which performs the same or similar function.
- **Data Quality Indicators.** Measures which characterize attributes of data or data sets.
- **Elementary Flow.** Any flow of raw material entering the system being studied and which has been drawn from the environment without previous human transformation; any flow of material leaving the system being studied and which is discarded into the environment without subsequent human transformation.
- **Environmental Aspect.** Element of an organization's activities or products which is likely to interact with the environment.
- **Function.** Performance characteristic of a product system.
- **Functional Unit.** Measure of performance of the main functional output of the product system.
- **Interested Party.** Individual or group concerned or affected by the environmental performance of a product, or by the results of the life cycle assessment.
- **Life Cycle.** Consecutive and inter-linked stages of a product system, from raw material acquisition or generation of natural resources to the final disposal.
- **Life Cycle Assessment.** Compilation and evaluation, according to a systematic set of procedures, of the inputs and outputs of materials and energy and the associated environmental impacts directly attributable to the function of a product throughout its

life cycle.

- **Life Cycle Classification.** Element of the life cycle impact assessment phase in which the inventory parameters are grouped together and sorted into a number of impact categories.
- **Life Cycle Environmental Impact.** Any change to the environment, whether adverse or beneficial, wholly or partially resulting from the input and output flows of a product system.
- **Life Cycle Impact Assessment.** Phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of environmental impacts based on the life cycle inventory analysis.
- **Life Cycle Interpretation.** Phase of life cycle assessment in which a synthesis is drawn from the findings of either the inventory analysis or the impact assessment, or both, in line with the defined goal and scope.
- **Life Cycle Inventory Analysis.** Phase of life cycle assessment involving compilation, and quantification of inputs and outputs, for a given product system throughout its life cycle.
- **Life Cycle Valuation.** Element of the life-cycle impact assessment phase in which the relative significance of the data from the inventory analysis or results of the characterization are established.
- **Practitioner.** Individual or group of people that provides the services to conduct a life cycle assessment study.
- **Product System.** Collection of materially and energetically connected unit processes which performs one or more defined functions.
- **Raw Material.** Primary or secondary recovered or recycled material that is used in a system to produce a product.
- **Raw Material Acquisition.** Activities associated with delivery of raw materials for use. These activities include exploration, extraction, and in the case of agriculture or forest products, cultivation and harvesting.
- **System.** Collection of unit processes which, when acting together, perform some defined function.
- **System Boundary.** Interface between the product being studied and its environment or other systems.
- **Transparency.** Objective and comprehensive presentation of information.
- **Unit Process.** Component of the system being studied that is a collection of operations which transform inputs into outputs.
- **Waste.** Any output which is disposed of from the product system.

10 ENVIRONMENTAL, HEALTH AND SAFETY RISK ASSESSMENTS IN RELATION TO ENVIRONMENTAL MANAGEMENT

MUHAMAD AWANG

INTRODUCTION

This chapter provides a conceptual overview of ecological/environmental, health and safety risk assessments in relation to environmental management to meet current and future trade globalization as partly required by the ISO 14000. The standards lay a common foundation for more uniform, efficient, and effective environmental management worldwide. The systems and tools comprise environmental management systems (EMS), environmental auditing (EA), environmental performance evaluation (EPE), environmental labeling (EL), life cycle assessment (LCA), environmental aspects in product standards (EAPS), and also terms and definitions. Conceptually, the standards are based on better environmental management that will lead to better environmental performance, increased efficiency and greater return on investment. It is categorized into two general groups, in which EMS, EA and EPE standards are used to evaluate the organization, while LCA, EL and EAPS are applied to product and process evaluation. The EPE, LCA, EL and EAPS processes cover the full life cycle of a company's products and services, from raw material input through production and disposal. These components need a full understanding not only of environmental/ecological risk assessment but also of health and safety measures. These risk assessments involve methods of system analysis through integrating aspects of ecology, environmental chemistry, environmental toxicology, hydrology, and other related earth sciences in order to estimate conditional probabilities of the occurrence of undesired events. It covers an integration of hazards identification, exposure assessment, exposure-response assessment, risk characterization and risk management. This chapter also discusses a proposed model for risk assessment and management needs to be practised in the country.

The benefits of a modern, industrial society that provide a high standard of living through production and consumption activities are impossible to achieve without risk. It has imposed numerous externalities. Expressions of concern for environmental issues such as air and water pollution, waste generation, ozone layer depletion, global warming and pesticide contamination, have increasingly become mainstream concerns in most developed and developing countries. As a consequence, the effective management of technological risk has become an increasingly significant concern of policy makers. Risk assessment and risk management provide the means for effectively dealing with these concerns. However, the nature of risk assessment and risk management is complex and diverse, involving immediate danger to individual health and safety as well as environmental/ecological and economic risks. It is recognized that formal analysis of risk as an input to decision making is a relatively new practice. It has been difficult both to adequately quantify risks and to subsequently include them in the decision-making process. The terminology used in analyzing, assessing and managing risk is often unclear and sometimes conflicting. In Malaysia, in order to respond to an increase in public interest, concern and demand for better control of hazards, more than twenty pieces of federal and state legislation and orders have been passed by the government over the last two decades (Table 1). Essentially, they can be categorized into eight components, namely, Agro-Based Water Pollution, Sewage and Industrial Waste Water Pollution, Industrial Emissions, Motor Vehicle Emissions, Toxic and Hazardous Waste, Integration of Environment and Development, Control of Substances that Deplete the Ozone Layer and Marine Pollution.

Present society also believes that rapid increase in population, dwindling supply of commercially valuable species, soil erosion, polluted water and air and other threats to natural resources have spurred governments and industry to assess the ecological impacts of human-induced stresses on the environment. In the past, the supply of natural resources was abundant and they were treated as having little value unless harvested for human benefits. The magnitude and diversity of anthropogenic activities that lead to disturbances to the environment and the natural complexity of ecological systems is hard to assess. The impacts on natural resources must be measured and assessed against a natural ecological background that is dynamic in space and time (Bartell, 1996). The evaluation is complicated by the fact that ecological systems are partially or incompletely understood. These complexities and uncertainties in assessment processes require that ecologists develop a well defined methodology especially in industrial sectors in order that they grow sustainably.

It is recognized that the integration of ecological/environmental, health and safety methodologies and risk assessments allows some flexibilities in providing the needs of environmental management systems (EMS). Ecological risk assessment (ERA) is designed to meet this need. Bartell et al., (1992) and Suter (1991) noted that the current practice of ERA uses methods of system analysis to integrate aspects of ecology, environmental chemistry, environmental toxicology, hydrology and other earth sciences to estimate conditional probabilities on the occurrence of undesired ecological events applicable to both natural and human impact on ecological resources. Such events are subjected to ecological risk assessment constituting an unbounded set of primarily negative impacts, ranging in theory across the entire spectrum of ecological measures. Clearly, ecological resources cannot be sustainably managed without a prescription regarding quality and quantity. Thus, embracing sustainable management as an overarching management objective, decision makers and risk managers are forced to delineate, in operational detail, the currently missing underlying environmental model (Bartell et al., 1992).

The first part of this chapter outlines some background information on environmental management system according to ISO 14000, and subsequently discusses ecological/

Table 1: Control Sector of Environment and Its Provisions by Law

Sector	Regulations/Order
Agro-Based Water Pollution	Environmental Quality (Licensing) Regulations, 1977 Environmental Quality (Prescribed Premises) (Crude Palm Oil) Regulations, 1977 (amendment) 1982 Environmental Quality (Prescribed Premises) (Crude Palm Oil) Order, 1977 Environmental Quality (Prescribed Premises) (Raw Natural Rubber) Regulations 1978 (Amendment) 1980 Environmental Quality (Prescribed Premises) (Raw Natural Rubber) (Amendment) Order 1978
Sewage and Industrial Waste Water Pollution	Environmental Quality (Sewage and Industrial Effluents) Regulations, 1979
Industrial Emissions Regulations, 1978	Environmental Quality (Clean Air) Environmental Quality (Compounding of Offences) Regulations, 1978
Motor Vehicle Emissions	Motor Vehicles (Control of Smoke and Gas Emissions) Rules 1977 (Made Under the Road Traffic Ordinance, 1958) Environmental Quality (Control of Lead Concentration in Motor Gasoline) Regulations 1985 Environmental Quality (Motor Vehicle Noise) Regulations, 1987 Environmental Quality (Control of Emission from Diesel Engines) Regulations, 1996 Environmental Quality (Control of Emission from Petrol Engines) Regulations, 1996
Toxic and Hazardous Waste	Environmental Quality (Scheduled Waste) Regulations, 1989 Environmental Quality (Prescribed Premises) (Scheduled Waste Treatment and Disposal Facilities) Regulations 1989 Environment Quality (Prescribed Premises) (Scheduled Waste Treatment and Disposal Facilities) Order 1989
Integration of Environment and Development	Environmental Quality (Prescribed Activities Environmental Impact Development Assessment) Order 1987 Sarawak Natural Resources and Environment (Prescribed Activities) Order, 1994
Control of Substances that Deplete the Ozone Layer	Environmental Quality (Prohibition on the Use of Chlorofluorocarbons and Other Gases as Propellants and Blowing Agent) Order 1993 Environmental Quality (Prohibition on the Use of Controlled Substances in Soap, Synthetic Detergent and Other Cleaning Agents) Order 1995
Marine Pollution	Environmental Quality (Delegation of Powers on Marine Pollution Control) Order 1993 Environmental Quality (Delegation of Powers on Marine Pollution Control) Order 1994

(Source: Golden Hope Plantation Berhad, 1997) environmental risk assessment frameworks and ecological research needed. The research output will generate baseline information for environmental performance evaluation (EPE) and environmental performance indicator (EPI) requirements stipulated under SC4 and also life cycle assessment (LCA) under SC5 of ISO 14000. These EPE, EPI and LCA not only provide insight into problem areas and opportunities for improvement of a company and measure performance over time but also help in managing every element of the environmental management process. Such a process includes risk management and environmental accounting that help decision makers to measure and quantify the benefits of pollution prevention in the design of products and processes. The EPE will ensure that the system creates a basis for pollution prevention, better allocation of resources and better regulatory compliance. The second part of the chapter discusses health and safety risk assessments and their relation to management covering a similar approach adopted in ecological/environmental risk assessment. Finally, the chapter includes a proposed model for the Malaysian environment which is a slight modification of the US and Canadian models.

ENVIRONMENTAL/ECOLOGICAL RISK ASSESSMENT

Concept

Risk often refers to a conditional probability of a specified event occurring combined with some evaluation of the consequences of the event. An ecological environmental risk assessment refers to the conditional probability of a specified ecological event occurring, coupled with some statement of its ecological consequences, such as reduced biodiversity, loss of commercially valuable resources, or terrestrial and aquatic ecosystem instability. In contrast to the current practice, assessing ecological risk entails describing, either quantitatively or qualitatively the likely occurrence of a undesired ecological event without addressing the consequences. Helton (1993) describes the Kaplan-Garrick risk model involving at least three basic elements : (1) an undesired event that is the subject of the analysis, the endpoints. The element that might be unacceptable decrease in the reproductive potential of a species, or decreased genetic fitness of a population, or diminished primary production in a valued ecosystem, (2) an estimate of the conditional probability of the first element occurring that covers the results of risk analysis and estimation, representing the integration of exposure assessment and effects assessment which constitute risk characterization, and (3) an evaluation of the consequences (the loss or damage function) of the first element occurring. This element appears to be the least well developed component of ecological risk assessment. It might be expressed in monetary terms, ecological significance, moral/ethical considerations, aesthetics, or some combination of these values.

It is apparent that in environmental impact assessment (EIA) practice, uncertainties in the form of assumptions, incomplete data, bias, and imprecision are commonly implicit, hidden, overlooked, forgotten, or not rigorously incorporated into the assessment. However, in the case of risk assessment, these assumptions and uncertainties should be propagated throughout the analysis to produce a probabilistic statement concerning the chance of observing the assessment endpoint. Thus, the fundamental distinction between ecological risk assessment and environmental impact assessment is the explicit consideration of uncertainties (Bartell, 1996). It is desirable that the environment impact assessment (EIA) practices in Malaysia require an ecological risk assessment approach in the future.

In the US, ecological risk assessments have become integral components in the management and remediation of contaminated waste sites under the Resource Conservation and Recovery Act 1976. In addition, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) is a key driving force as it specifically mandates an ecological risk assessment in addition to human health assessment. The assessments cover catalogues of species to more detailed analyses of habitat disruption and, in rare instances, actual estimates of risk (Suter, 1991). Kopp and Smith (1993) pointed out that as a follow-up of the CERCLA, the Superfund Amendments and Authorization Act (SARA) of 1986 provides compensation for damages to natural resources that remain after remediation and restoration of Superfund sites; the Natural Resource Damage Assessments (NRDA) evaluate risks posed to current and future values of ecological resources, both direct use and non-use, and serve as another regulatory driver for performing ecological risk assessment.

Environmental Risk Assessment is also becoming increasingly important in the registration of pesticides under Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). FIFRA addresses chemicals that are known to be toxic and that are intended for application in the environment. Manufacturers must provide data that describe the environmental chemistry and toxicity of the proposed pesticides in order to assist the Environmental Protection Agency in the evaluation and regulation of these chemicals. The regulation also provides one technical advantage in the long term studies under large-scale field conditions can be demanded by the regulatory agency, circumventing somewhat the need for new methods that forecast ecological risk. Under the Toxic Substance Control Act of 1976, risk assessment is increasingly used in deciding whether to permit the manufacture, distribution, and use of new industrial chemicals.

It has been suggested that the concepts and methods used to study ecological responses to natural disturbances should be explored for application to Environmental Risk Assessment. Furthermore, the incorporation of disturbance theory into the risk estimation process proves to be valuable in formulating a framework or guidelines for ecological risk assessments. An ecological risk can be thought of as ecological disturbance cast in a probabilistic framework and described as a conditional probability. Risk assessment extends impact assessment by explicitly incorporating the uncertainties that enter the assessment in the calculation and characterizations of ecological impact. Among the sources of potential risks that are addressed in some of the studies are included radioisotopes, toxic gases, genetically engineered microbes, synthetic organic compounds, toxic metals and agricultural biocides. Surface waters and sediments appeared to be the most important media of exposure through transport pathways mechanisms typically either involving surface run-off, precipitation or processes that deposit contaminants into surface waters, and eventually to sediments. The levels of ecological organization such as physiological processes, individual organisms, population, communities, ecosystems, watersheds and larger regions will be determined in order to represent the selection of end points for the case study of the risk assessment. According to Bartell (1996) the common approach for assessing ecological risks has relied on direct (or simulated) measures of environmental concentrations of contaminants, the use of relevant toxicity data for species measured under laboratory conditions, and simple comparison of the exposure concentrations to these toxicity benchmark concentrations which is normally referred to as the hazard quotient.

In the US also, at least three conceptual frameworks have been established for assessing ecological risk; the National Research Council, the Water Environment Research Foundation and the United State Environment Protection Agency frameworks, respectively. Basically, the first framework involving the National Research Committee convened a Committee on Risk Assessment Methodology (CRAM) with the intention to connect scientific, technical understanding of issues to the decision making or regulatory process that should be functioning not only to ecological risk assessment but also to human health (Barnthouse, 1993). CRAM defines ecological risk assessment as the characterization of the adverse ecological effects of environmental exposures to hazards imposed by human activities. It covers hazard identifications (determines if a particular agent is associated with human health or ecological effects that are important enough to require detailed scientific study or need immediate risk management), exposure assessment (determines the extent of the exposure to the hazardous agent, either before or after regulation), exposure-response assessment (determines the relation between the magnitude of exposure and the probability of the ecological effect occurring), and risk characterization (describes the nature and magnitude of the risk, including consideration of uncertainties that entered into the assessment, expressing the risk in terms easily understood by the decision makers and the public). In this particular case, all phases of the assessment will include research, validation, and monitoring occurring jointly (Figure 1). The framework emphasizes the need to tailor the science of risk assessment to the capabilities of decision makers insisting on science adequate to the task of credible assessment in combination with qualified decision makers and an educated public. It is a policy-driven assessment and risk management is regarded as an integral part of the framework. The framework also attempts to conform ecological risk assessment with currently accepted approaches for assessing human health risk. Essentially, Figure 1 provides a conceptual overview of and guidance for performing an ecological risk assessment in relation to life-cycle assessment required by the ISO 14000.

As mentioned earlier, another important framework established in the US is developed by the Water Environment Research Foundation (WERF) based on USEPA 1992 framework to assess ecological risk posed by the chemicals in aquatic ecosystems (Parkhurst, 1993). It is a three-tiered methodology, involving (1) screening level risk assessment, (2) risk quantification with existing data, and (3) risk quantification with new data. Essentially, the methodology comprises problem definition (step to identify what is potentially at risk and what ecological resources should be protected in relation to any investment in remediation), source characterization (examines the origins of contamination and identifies the chemicals of concern in the assessment), exposure assessment (identifies the major pathways of contaminants transport through the environment and quantifies the expected environmental concentrations in relation to the source by delineating the distribution and environmental fate of the chemicals. It will assist in identifying which ecological resources might be placed at risk), ecological receptor characterization (the ecological components of the assessment are identified in part by the nature of the release and the relevant spatial-temporal scales associated with the transport and distribution of the pollutants being assessed), ecological effects characterization (pollutant concentrations that produce adverse effects in the ecological receptors are estimated for each chemical of interest in the assessment), risk characterization (to compare the expected environmental concentrations with the ecological risk criteria to assess risk) and risk management (a step to determine the future course of action regarding remediation). This approach has been successfully used for assessing the potential ecological risk posed by acid mines drainage (Cardwell et al., 1993) including the screening level assessment, risk quantification with existing data assessment and addressing both acute and chronic toxicity for stream assemblage consisting of plankton, benthic invertebrates and fish. In short, this framework emphasizes a sequential approach to risk assessment, using an initial screening calculation, followed by more detailed assessment with existing or newly acquired data.

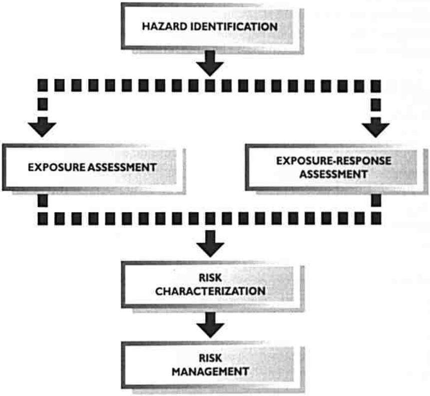

Figure 1: General Flowchart for the Process of Ecological Risk Assessment (Redrawn from Barnthouse et al., 1990)

The third framework developed by the Environmental Protection Agency (USEPA) provides an integration of risk management with risk analysis in the problem formulation phase, but separates analysis from management during the assessment process (Bartell, 1996). It is understood that ecological risk assessment is defined as "... to evaluate the likelihood that adverse ecological effects will occur.....as a result of human activities" (Norton et al., 1993). It allows semiquantitative and qualitative expressions of risk in addition to probabilistic estimates implied in the definition. The USEPA also identifies problem formulation, exposure and effects assessment, and risk characterization as the necessary components of an ecological risk assessment.

Approach

Problem Formulation Phase

Perhaps adopting the third framework provided by the USEPA would allow our plantation sectors the most benefit, provided the model be viewed as dynamic and subject to refinement and modification in light of our different environment and of changing assessment objectives and the development of new information. In this case, the problem formulation step is the most important in determining the contribution of the risk assessment to risk management. The phase delineates the nature and scope of the assessment, characterizes the sources of potential ecological risk, identifies ecological resources at risk, and produces a conceptual model of the assessment. Then, it is followed by interactions among risk managers and risk assessors.

In formulating an ecological risk assessment, risk managers and risk assessors are particularly interested in determining the timing (when the stressor occurs), frequency (how often), magnitude (intensity of the stress) and duration (the time span) of the stressor. Stressor refers to the source or cause of ecological risks that could be either physical, biological or chemical in nature. Box 1 summarizes some of the stressors in ecological risk assessment. The physical stressors tend to cause habitat alteration or habitat loss or direct mortality of susceptible organisms, whilst biological stressors include the introduction of exotic species and pest outbreak and chemical stressors include biocides, fertilizers, and other compounds that may occur naturally or synthetically. The stressor profile provides information for identifying ecological resources potentially at risk and also by characterizing the stressor it will provide insight into possible endpoints (an ecological effect selected as a focus for risk characterization) for the assessment. Selection of ecological endpoints will determine in large part the efficacy of any particular assessment as the entire process is contingent on the nature of the endpoints. This will affect the decision criteria, and subsequently will influence the accuracy and precision in estimating the probability of the endpoint occurring, and also in evaluating the ecological consequences of the event.

Bartell (1996) pointed out that in order to facilitate the risk estimation, a selected ecological effect should be measurable with sufficient statistical power for a feasible investment in sampling and analysis. The effects of disturbance or chemical toxicity can be measured at different levels of biological and ecological organization covering the effects on individuals, populations, communities, ecosystems, watersheds, and landscape. However, according to

Bartell (1993) more than 90% of reported ecological assessments focus on changes in the abundance of one or more populations as the effect of principal ecological concern. Suter (1989), USEPA (1992) proposed the endpoints should be consistent with the policy goals or the mandates of legislation that require assessment. Thus, social, political and economic attributes are important in addition to ecological considerations in selecting endpoints for risk analysis. These attributes, framed in human values, provide the link between ecological risk assessment and a broader environmental context which gives meaning to the assessment (Bartell, 1996). Moreover, the consequences of an occurrence should play an important part in defining an ecological endpoint for risk assessment and should also be transparent and accepted by the risk managers, decision makers, and other stakeholders.

In order to be in line with the decision making, it is important to recognize that one principal way to increase the economy and effectiveness of risk assessment is to specify in advance the accuracy and precision required of the risk estimates in order to provide a meaningful input to the risk management process. In addition, the assessment team should view the overall process as a series of iterations between risk managers and risk assessors. Aims and objectives of the overall assessment need to be clearly specified as the information will be utilized by the assessors in determining (1) what data are needed, (2) how to best quantify exposures, (3) what ecological resources might be at risk and (4) what tools to use for integrating all the information into results consistent in format with the needs of the risk managers. In turn, the assessor must be able to discuss openly with managers (1) the objectives of the assessment and to indicate what reasonable endpoints might be, (2) data that are readily available, (3) the nature of the uncertainties, and (4) the implications for successfully addressing the overall assessment objectives. The USEPA also summarizes the components

EXAMPLE STRESSORS IN ECOLOGICAL RISK ASSESSMENT

PHYSICAL STRESSORS

- Severe erosion
- Excessive sediment loading
- Extreme meteorological events (e.g. tornadoes, hurricanes, fires)
- Habitat loss (e.g. filling of wetlands, urban development)
- Increased ultraviolet radiation

BIOLOGICAL STRESSORS

- Pest outbreaks (e.g. spruce budworm, gypsy moths)
- Exotic species introductions (e.g. kudzu, grass carp, alewife, zebra mussel)
- Viruses and other pathogens

CHEMICAL STRESSORS

- Organic chemicals [e.g. polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenylis (PCBs)
- Pesticides
- Toxic metals (e.g. selenium, copper, cadmium, nickel, lead)
- Radionuclides (e.g. plutonium, uranium, cesium)
- Gases (e.g. sulfur dioxide, nitrous oxide, ozone, greenhouse gases)

BOX 1

(Source: Bartell, 1996)

of the problem formulation phase as a conceptual model in the form of a flow diagram for the overall assessment as illustrated by Suter (1989).

Exposure Assessment and Dose

This determines the mechanisms that bring organisms into contact with the source of the potential ecological risk by quantifying the frequency, magnitude, and duration of such contact. The contact could be through physical (dermal) contact, inhalation, drinking contaminated fluid, or ingestion of contaminated food and is normally referred to as the primary pathway of exposure. It is very much influenced by the characteristics of life history, behaviour, dynamics of growth, migration, and also geographical distribution of the selected species. In characterizing exposure of selected ecological endpoints, it needs to specify the important spatial and temporal scales over which exposure (and dose) must be quantified. Dose can be estimated as the product of the chemical concentration in the source medium (air, water, soil, food) multiplied by the rate of inhalation, drinking and ingestion or degree of physical contact. It is routinely expressed as mass of chemical per unit mass of organism. The nature of the endpoint in a specific environmental medium will determine the appropriate averaging time for exposure. In terms of transport and distribution, the environmental chemistry of contaminants and their physico-chemical processes can influence the relative distribution and concentrations of the contaminants among different environmental media (Mills, 1992).

In the case of biological processes, it can be important in transporting and distributing ecological stressors, particularly when mobile organisms are themselves the stressors. These transport and distribution processes also need to be quantified in terms of their frequency, magnitude and duration of exposure as it is critical to the overall assessment. In a sequential approach to risk assessment, several methods have been proposed for exposure assessment (Bartell, 1996). These methods include, (1) worst-case scenario, using the greatest expected magnitude of the stress which is certainly biased toward predicting effects when they might not actually occur in the natural environment, (2) actually measuring, the exposures perhaps represents which the most scientifically defensible approach to exposure assessment. It is subjected to the concerns of sampling design, sample collection and processing, analytical procedures, and other potential sources of variations in values, and (3) mathematical or physical models which might be constructed to estimate exposure.

Ecological Effects and Stress-Response Relationships

Estimating the relationship between exposure, dose, and response constitutes the next important phase of ecological risk assessment. Toxic chemicals exert their fundamental influence at the level of chemical reactions through a complex array of biochemical reactions that may be blocked or altered kinetically by the presence of xenobiotics. The impacts of altered reactions are subsequently assessed at the appropriate biological or ecological level of organization (the individual, community, or ecosystem) that determines the accuracy of the endpoints selection. It has been suggested (Allen and Starr, 1982; Holling, 1986; King, 1991) that the advances in ecological understanding achieved through decades of basic study of each different level offer unique and potentially powerful concepts and measurements that should be incorporated into the development and application of ecological risk assessment. In addition, competent attempts at integrating across these levels should be explored for their relevance in selecting endpoints for environmental risk assessment. Conceptual rigor in addressing levels of organizations assumes paramount importance in risk estimation because ecological responses to specific disturbances are expected and anticipated at one or more of these levels (USEPA, 1992).

Risk Characterization

Essentially, this is the penultimate step in the ecological risk assessment process involving screening calculations, hazard quotients, quotient index (Cardwell et al.,1993), joint distributions, hypothesis testing and modeling (Barnthouse et al., 1990; Bartell, 1990 and Bartell et al., 1992). It integrates the assessment of the nature and magnitude of the ecological stress with the stress-response relations and provides an estimate of ecological risk. An important aspect of risk characterization extends beyond basic risk estimation to include a quantitative consideration of the uncertainties that entered into risk estimation, and their potential impact on the resulting risk estimates (Bartell, 1996). Basically, a variety of methods and tools are available to perform the risk characterization, ranging from simple screening-level calculations to complex ecosystem models including the discussion of uncertainties that lead into the risk management processes. Those methodologies require some fundamental ecological research that could satisfy desirable attributes of an ecological risk methodology (Box 2). An example format for a risk assessment report is provided in Box 3.

DESIRABLE ATTRIBUTES OF AN ECOLOGICAL RISK METHODOLOGY

- The method should be coherent, that is, different practitioners given the same problem and information should arrive at similar estimates of risk.
- The method should be capable of using information and data currently collected by the ecological community as input to the assessment process. e.g. acute and chronic toxicity data.
- The method should be based on modern, quantitative understanding of ecological systems.
- The methods should reflect a solid foundation in environmental toxicology and dose-response relationships.
- The results of the assessment should fit conveniently into a framework that accounts for uncertainties and estimates risk as a conditional probability.
- Risk estimates produced by the methods should be verifiable using measurements or experiments.

(Source: Bartell et al., 1992.)

BOX 2

EXAMPLE FORMAT FOR RISK ASSESSMENT REPORT (BARTELL, 1996)

REMEDIAL INVESTIGATION/FEASIBILITY STUDY REPORT OUTLINE

INTRODUCTION
- Regulatory initiative
- Restoration program
- Objectives and scope
- Schedule

CHARACTERISATION OF ENVIRONMENTAL SETTING
- Geography
- Demography
- Climate
- Topography, geology, and soils
- Surface waters
- Sediment
- Ecology
  - Terrestrial resources
  - Aquatic resources

SITE HISTORY AND CURRENT CONDITIONS
- Release history
- Summary of existing conditions
- Summary of site characterization results

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
- **Chemical-specific ARARs**
  - Surface water
  - Sediment
- **Location-specific ARARs**
  - Wetlands and flood plains
  - Aquatic resources
  - Endangered and threatened species
  - Archaeological resources
- **Radiation protection standards**

HUMAN HEALTH ASSESSMENT
- **Identification of contaminants of concern**
  - Data collection and evaluation
- **Exposure assessment**
  - Characterization of exposure setting
  - Exposure scenarios
  - Quantification of exposure

BOX 3

TOXICITY ASSESSMENT

Risk characterization

- Current land-use conditions
- Future land-use conditions
- Risk characterization summary

BASELINE ECOLOGICAL RISK ASSESSMENT

Ecological hazard identification

- Ecological endpoints
- Environmental description
- Sources
- Conceptual models

EXPOSURE ASSESSMENT

- Aqueous exposures
- Sediment exposures
- Wildlife exposures
- Soil exposures

EFFECTS ASSESSMENT

- Conventional toxicity data
- Media toxicity data
- Biological survey data

RISK CHARACTERIZATION

- Risk integration for current conditions
- Risk integration for future conditions
- Uncertainties
- Comparison to human health risks

REMEDIATION GOALS

Development of alternatives

- Background
- Technology screening and evaluation
- Assembly of alternatives
- Detailed description of alternatives
- Action-specific ARARs for each alternative

ENVIRONMENTAL CONSEQUENCES OF REMEDIATION ALTERNATIVES

etc.

BOX 3 (Cont'd)

Ecological Research

Underwood (1995) provides a very comprehensive overview of ecological research (and research into) environmental management. Figure 2 illustrates a diagrammatic representation of some relationships between ecological research and environmental managerial decision-making. At least four types of research have been identified which interact with one another and also with management to influence the outcome of decision-making: (1) available pool of research - the material presented to or used by management agencies when they have defined a problem and need data to use in reaching decisions about what to do to solve the problem, (2) applied and environmental research - aimed at specific tests of the results of the decisions made by managers by treating this decisions as testable hypotheses, (3) new, basic and strategic research - to develop new theories and understanding when former managerial decisions fail, and (4) managerial research - designed to investigate the processes management and the procedures by which decisions are reached using the information provided under category (1). As mentioned earlier, the major points to be explored here are the relationship between ecological research and decision making about environmental disturbances, disposal of waste, conservation of species and habitat, and exploitation of biological resources.

Although ecological risk assessment remains an emerging discipline in both concept and method, information generated through ecological research will enhance the process of environmental performance evaluation (EPE) and environmental performance indicators (EPI). EPE and EPI incorporate ways to describe and measure the environmental impacts of the organization's activities. These impacts can be local, regional or global included in the following areas (Tibor and Feldman, 1996): (1) landuse (such as impacts on wetlands, on desertification and erosion, or increase in loss of nutrients from soil), (2) biological diversity (such as acidification of water and resulting fish deaths), (3) ecological (such as global climate conditions, evidenced by changes in precipitation, higher global temperature, sea-level rise, etc.), and (4) human health (such as toxicological impacts). The primary use of the state-of-the-environment classification is as a context for selecting specific indicators that measure the impacts on the environment from the organization's activities, products and services. In addition, an EPI also emphasizes (a) the number of toxic release incidents over a specific period of time, (b) number of incidents investigated and determination of root causes, (c) percent reduction in transportation energy, (d) air pollution emission in kg/unit production, (e) discharge of effluents in kg/unit of production, (f) hazardous waste generated in kg, (g) weight of packaging per unit consumer product, and (h) amount of carbon dioxide released into the atmosphere. Box 3 outlines an example format for an ecological risk assessment report provided by the USEPA (1992).

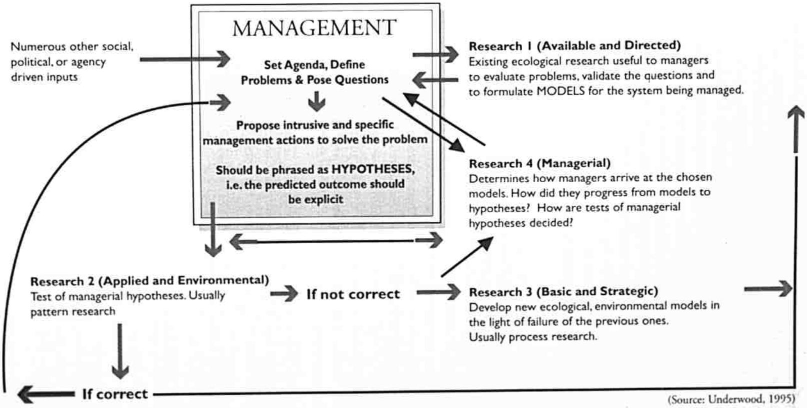

Figure 2: Diagrammatic representation of some relationships between ecological research and environmental managerial decision-making. Four types of research are illustrated: (1) Strategic research to provide data for managers, (2) Applied research to examine the outcome of managerial decisions, by treating them as testable hypothesis, (3) New basic research into processes to replace models used when management goes wrong, and (4) Analysis of the processes of management.

The process of evaluating and measuring environmental impacts, however, is complex, and their correlations are difficult to identify. In spite of that, more companies are taking a closer look at EPE and EPI and the entire life cycle of their products, from the raw material extraction process through production, possible reuse and disposal as the life cycle concept helps them to make better business and environmental decision. In addition, using a life cycle inventory analysis, LCA, can help a company identify opportunities to reduce emissions and energy and material use. LCA is also a risk management tool that helps companies/organizations understand the environmental risks throughout the product/process life cycle. Moreover, if the company has developed an EPE program, the LCA process can improve the precision and accuracy of EPI (Tibor and Feldman, 1996).

HUMAN HEALTH RISK ASSESSMENT

Approach

Human beings are exposed daily to myriad sources of chemical, physical, and biological hazards directly or indirectly, including industrial discharges, vehicular emissions, hazardous waste site releases, agricultural chemicals, cold and flu viruses and other natural processes. These exposures can lead to either safety risk (acute hazard) or health risk (derived from chronic exposures to low concentrations typical of environmental exposures). In general, human beings are in a dynamic equilibrium with their environment and constantly receive beneficial and hazardous agents that continually accumulate and transform. Although over the millennia, humans as well as animals and plants have evolved elaborate protective mechanisms, including detoxifying and homeostatic (self-regulating) mechanisms, however, when the protective mechanisms that serve us well are disrupted or overloaded, human beings will face the consequences.

Risk is a function of the nature of the hazard, accessibility or avenues of contact (exposure potential), characteristics of exposed populations (receptors), and the likelihood of occurrence of exposures and consequences. As described earlier, the consequences of different types of risk are generally expressed in terms of safety (fatalities and injuries), health (cancer and non-cancer effects), public welfare (aesthetics, nuisance conditions), ecology (species diversity, habitat loss), financial issues (property loss, liability), or a combination of these. As a shortcut approach due to limitations in resources and methodologies, risk assessment tends to focus on a few extreme situations, ignoring probabilities of some occurrences that are fundamental to the risk concept. In human health risk assessment, the consequences or endpoints are grouped into cancer risk and a 'catch-all' non-cancer risk category. The former drives regulatory decisions as cancer is an unambiguous endpoint and deeply dreaded by the public and its assessment methodology is well established, whilst the latter encompasses a diverse set of effects or endpoints, including temporary and reversible enzyme changes, immune suppression, reproductive and developmental abnormalities, and respiratory and allergic reactions.

In the case of health risk assessment and management, the National Research Council of the US (NRC, 1983) also provides a four-step process (Figure 1) that consists of hazard identification, dose-response assessment, exposure assessment and risk characterisation (as discussed previously). On developing risk measures for health and safety (Figure 3) and in relation to hierarchy of risk evaluation categories for the purpose of management (Figure 4), the process is oriented towards quantifying risks associated with hazardous chemicals from industrial operations and contaminated sites (Kolluru and Brooks, 1996). The risk assessment starts off with an initial phase of research and data collection. Hazard data may come from historical records and sampling environmental media (air, water and soil and sediment) on and off site, while the toxicity data may be obtained from animal experiments, worker occupational exposure, epidemeologic studies, medical or clinical records, and structure-activity relationships. The subsequent phase involves setting remediation goals, screening alternatives, and implementing a selected course of action in the context of political, social, and economic considerations.

Kolluru (1996a) proposed at least four major steps in a baseline of human health risk assessments need to be considered: (1) data evaluation and hazard identification, (2) toxicity or dose-response assessment, (3) exposure assessment, and (4) risk characterization including uncertainty and sensitivity analysis.

Data Evaluation and Hazard Identification

The main objective of having data quality assurance is to provide statements that specify the quality and quantity of data required to support regulatory and non-regulatory decisions. It should reflect all identified uses, including risk assessment (human, ecological), treatability studies, applicable or relevant and appropriate requirements and remedial action that will satisfy the following questions (Kolluru, 1996a):

1. What are the expected uses of the data, and who will use them?
2. Should the data be collected, analyzed and validated according to established protocol?
3. What kind of sampling program is appropriate to the site - purposive, biased (near 'hot spot'), random, systematic, or a combination of these?
4. Is the list of analyses appropriate to the site? What level of confidence is required? Does only a subset need to be analyzed based on site production or use history? How many samples are needed?
5. Are quantitation and detection limits of analytical methods sufficiently low, i.e. below health based reference concentrations?
6. Are background and off-site samples to be collected and where?

In addition, the nature and the existence of the chemicals of concern and site-specific chemistry needs to be looked into as their presence is a necessary but not sufficient condition for health and safety risks or vice-versa. These distinctions need to be made as the public perception is always that: hazard = exposure = risk = personal injury. Chemicals of potential concern can be screened and prioritized on the basis of their toxicity, concentration in the environment (media), frequency of detection, fate and transport characteristics and pathways.

Toxicity Assessment

Essentially, toxicity assessment is done to estimate the potential for selected chemicals to cause adverse effects in exposed populations and to provide an estimate of the relationship between the extent of exposure and the increased likelihood of adverse effects — in short, to establish the dose-response relationship. In the past, most of the toxicity data were derived from animal experiments that provided a dose-response relationship indicating the degree of toxicity to the exposed species. Response or effect among different species to a specific chemical can vary widely, perhaps from no observable effect to temporary and reversible (such as enzyme depression caused by some pesticides) to permanent injury to organ to chronic functional impairment and finally to death. The data have also been derived from occupational, clinical and epidemeological studies.

Exposure Assessment

As mentioned earlier, most of us are exposed to varying degrees by multiple pathways and route of contaminants, and by definition, the process by which an organism comes into contact with a hazard is referred to as exposure. This exposure is essentially bridging the gap between a hazard and a risk. Exposure to contaminants from primary or secondary sources can occur *via* inhalation of air, ingestion of water and food, or absorption through skin contact, or directly in case of radiation. It has been recognized that among the important aspects of exposure assessment are contaminant sources, release mechanisms, transport and transformation characteristics, as well as the nature, location, and activity patterns of the exposed population ('receptors'). In addition, the key steps in exposure assessment are identification of potential receptor population, evaluation of exposure pathways and routes, and quantification of exposures. Hypothetically, at least four major elements are involved in exposure pathways and routes: (1) a source and release mechanism (e.g. volatilization, leaching, surface runoff), (2) a transport medium for released constituents (e.g. air, drinking water), (3) human or environmental receptors and an endpoint of contact with the contaminated medium, and (4) intake or uptake routes at the point of contact by a receptor (e.g. inhalation, ingestion, dermal absorption). It is understood that without these links, an exposure pathway would be considered incomplete and therefore not contributing to risk by that pathway.

Another parameter that needs to be considered is the contaminant fate and transport as contaminants can be transported within and between different media. A contaminant could , be transformed into a more or less toxic form and attenuated or concentrated by biodegradation or bio-accumulation. These processes depend on their physico-chemical and biological properties or characteristics of the contaminant and those of the environmental medium. Exposure quantification is a subsequent step in the process which deals with the quantification of the magnitude, frequency and duration of exposure for all the pathways that are considered complete and significant. This involves estimation of exposure point concentrations for chemicals of concern and calculation of intake or dose that requires equations with three sets of variables, namely: (1) chemical concentrations in media at exposure points, (could be derived from measured, monitored, and/or modelled data), (2)

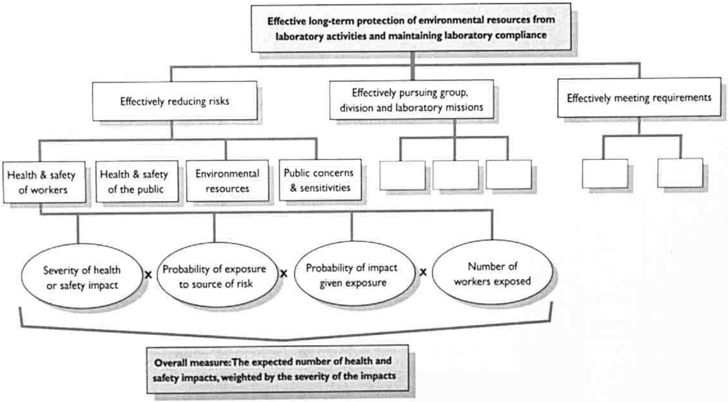

Figure 3: Developing a Risk Measure for Health and Safety (Source: Kolluru and Brooks, 1996)

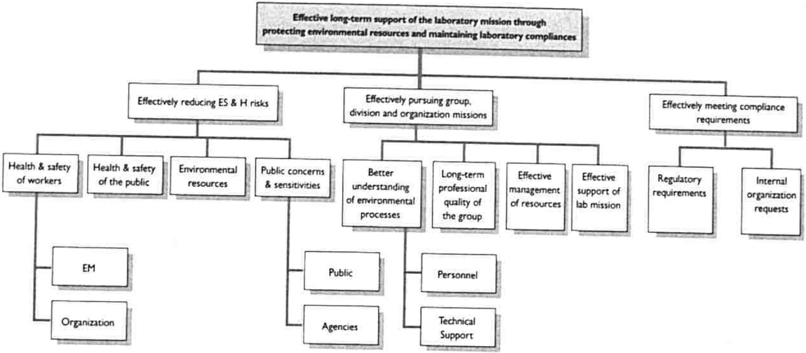

Figure 4: Hierarchy of Risk Evaluation Categories developed by EM Division (Source: Kolluru and Brooks, 1996)

contact rates (magnitude, frequency and duration), and (3) biological characteristics of receptors (body weight, absorption). A great deal of professional judgement and a combination of monitoring and modeling of data is required to estimate exposure concentrations. In the case of exposure rate and receptor biological data, site specific values should be used to the extent feasible. Conservative default values suggested by the USEPA can be used (EPA, Supplementary Guidance, March 25, 1991- OSWER Directive 9285.6-03) as illustrated in Table 2.

Table 2: EPA Default Exposure Factors•

Land use	Exposure Pathway	Daily Intake	Exposure Frequency days/years	Exposure Duration days/years	Body weight, kg
Residential	Ingestion of potable water	2 L (adult) 1 L (child)	350	30	70 (adult) 15 (child)
	Ingestion of soil and dust	200 mg (child) 100 mg (adult)	350	6 24	15 (child) 70 (adult)
	Inhalation of contaminants	20 m^3 (adult) 12 m^3 (child)	350	30	70
Industrial and commercial	Ingestion of potable water	1 L	250	25	70
	Inhalation of contaminants	20 m^3 (workday)	250	25	70
Agricultural	Consumption of homegrown produce	42 g (fruit) 80 g (veg.)	350	30	70
Recreational	Consumption of locally caught fish	54 g	350	30	70

• Factors presented are those that should generally be used to assess exposures associated with a designated land use. Site-specific data may warrant deviation from these values: however, use of alternate values should be justified and documented in the risk assessment report. Listed pathways may not be relevant for all sites, and other exposure pathways may need to be evaluated owing to site conditions. Factors shown are for adults unless specified otherwise.

For dermal exposure, chemical-specific permeability coefficients or absorption factors would also be needed. If permeability is less than 10-1 cm/h for water, or absorption less than 10% for soil, dermal route may not be important (EPA Dermal Exposure Assessment, 1992).

† Agriculture ingestion of water and soil, and inhalation of contaminants same as Residential.

Source: EPA Supplemental Guidance. March 25, 1991 (OSWER Directive 9285.6-03)

Risk Characterization, Uncertainty and Sensitivity Analysis

The integration of the toxicity assessment and the exposure assessment depicts quantitative estimates of cancer risks and hazard indices, while risk characterization is the interactive process of extracting and integrating decision-relevant information from hazard, dose-response and exposure evaluation and rendering it comprehensible to a diversity of users. In short, risk characterization is an iterative process and is a bridge between risk assessment and risk management.

SUMMARY OF RESULTS AND RECOMMENDATIONS

1. **Introduction**
   a. Facility setting and operational history
   b. Objectives and scope
   c. Approaches and methodology

2. **Contaminants and areas of concern**
   a. Site data review and screening
   b. Chemicals of potential concern
   c. Sub-areas or units of interest

3. **Toxicity or dose-response assessment**
   a. Cancer and noncancer responses
   b. Toxicity data for chemicals of concern

4. **Exposure assessment**
   a. Land use and exposure scenarios
   b. Exposure pathways and potential receptors
   c. Exposure quantification

5. **Health risk characterization**
   a. Cancer and noncancer risks
   b. Major contributors of risk
   c. Population risks and public healths
   d. Related studies (e.g. ATSDR, State, Country, city DOH)

6. **Safety risk screening**
   a. Hazardous materials
   b. Hazardous structures and conditions

7. **Public welfare risk screening**
   a. Restrictions on public resource use
   b. Nuisance conditions (e.g. odors, aesthetics)

8. **Uncertainty and sensitivity analysis**

9. **Preliminary risk management goals**

10. **References**

11. **Appendices**

BOX 4: Baseline Risk Assessment Report
(Source : Kolluru, 1996)

It is realized that at every step of the risk assessment process there is always an element of uncertainty. Among the sources of uncertainty are natural variability, model validity, and simple ignorance. In order to appreciate the limitations and significance of risk estimates, it is important to have some understanding of the nature and magnitude of the uncertainty in among others (Kolluru, 1996a), site characterization, toxicity assessment, exposure assessment, risk characterization, sensitivity analyses, probabilistic risk estimates and uncertainty and variability. Box 4 provides an example of a summary of results and recommendations for a Baseline Health Risk Assessment Report (Kolluru, 1996a).

OBJECTIVES, ADVANTAGES AND LIMITATIONS OF RISK ASSESSMENT

As risk assessments allow us to set environmental priorities and to target national resources, the main objective of risk assessment is to decide on the need for and the nature of risk management. Box 5 highlights key objectives, advantages and limitations of risk assessment (Kolluru, 1996). Basically, risk criteria provide an effective frame of reference for prioritizing problems, allocating resources and reducing risks. Results of hazard and risk analyses can be utilized for targeting action-sensitive hazards, in which areas, sources, or situations, where the greatest reductions in risk can be achieved from unit deployment of resources. In financial terms, resources can be leveraged. Empirically, it is proven that 'well designed', targeted risk analyses can yield saving of 5 to 20 percent of the total project cost by focusing on the highest sources of risk and reducing associated uncertainty.

Kolluru (1996) also pointed out that the paucity of professionals who have the broad training and the perspective needed to transcend the 'cookbook' approach and focus on the critical issues is the most crucial limitation to realizing the full potential of risk assessments (Box 5 and Box 6). In addition, there is no concrete scientific consensus on the approach and the purpose that risk analyses should serve, as the magnitude of uncertainty sometimes tends to detract from the science of risk assessment. Furthermore, risk estimates are typically of two to three orders of magnitude of uncertainty, and for this and other reasons, many believe that risk expressions are an attempt to obfuscate responses to the simple question: 'Is it safe or unsafe?'. Among the professionals, risk assessment is perceived to be a tool to prove that there is little or no risk. Moreover, risk assessment professionals have to serve multiple clients with diverse interests. Consequently, the ultimate objectives: 'public health' could easily be overlooked. Box 6 summarizes the applications of risk assessments in a variety of situations (Kolluru, 1996).

Among the major federal agencies that routinely use risk assessments in the USA are USEPA, Food Drug Administration (FDA), Occupational Safety and Health Administration (OSHA), Consumer Product Safety Commission (CPSC), Department of Transport (DOT) and Department of Agriculture (USDA). In Malaysia, the Department of Environment (DOE), Department of Agriculture (DOA) and Ministry of Health (MOH) are among the most important federal agencies responsible for safety, health and ecological risk assessments.

OBJECTIVES

- To obtain perspective on different sources and nature of risk to gain insight into risks across sources, space, and time
- To identify "worst" risks as well as investment-sensitive and time-sensitive risks
- To seek a systematic framework for optimal resource allocation to avoid or control risks

ADVANTAGES

- "Bottom line" public health and safety concerns addressed with a common language
- Systematic framework for prioritizing problems, allocating resources, and avoiding future problems
- Use of situation-specific factors rather than generic standards
- Scientific underpinnings for risk management
- Better control over costs and timing of implementation
- Resource effective, i.e. costs often saved by directing effects toward acting-sensitive hazards and exposures

LIMITATIONS

- No broad consensus on the purpose, the approach, or the results
- Risk is probabilitistic but standard methods are deterministic
- Orders-of-magnitude variability in health and ecological assessments, subjective
- Inadequate data, speculative nature of assumptions
- Site-specific risk assessments tend to be myopic, ignoring incremental and macro impacts
- Few qualified professionals with needed range of skills: risk assessors, engineers, and economists speak different languages
- Credibility and perception (or "pulling the wool over one's eyes")
- Multiple clients, diverse interests, unrealistic expectations

BOX 5 : Advantages and Limitations of Risk Assessments
(Source : Kolluru, 1996)

RELATIONSHIP BETWEEN RISK ASSESSMENT AND MANAGEMENT

As mentioned earlier, whether corporate or regulatory, risk management is the process of evaluating and if necessary, controlling sources of exposure and risk (Figures 5 and 6). It means weighing many different attributes of a decision and developing alternatives. Besides the input from scientific information provided by risk assessment, other criteria such as politics, economics, competing risks, equity and other social concerns are also included. It has been argued that although risk assessment is rooted in science, the usefulness of its results to risk management depend on the questions it is designed to answer, how it is conducted, and the way it is structured. Unfortunately, too many risk assessments prove to be of little value to risk managers because of inadequate planning.

APPLICATIONS

Risk assessments can be applied in variety of situations:

- Assess the benefits and costs of existing and proposed regulations
- Assess benefits (e.g. therapeutic effects) versus risks (e.g. side effects) of new drugs
- Appraise benefits (higher yields, less spoilage) versus risks (environmental media contamination, residues on food) of pesticide use
- Evaluate facility siting, process safety, and transport hazards to help select sites and routes and improve design
- Conduct baseline analysis of a site or facility to determine the need for remedial action and the extent of clean up required
- Develop clean-up goals for contaminants where numerical standards have not been promulgated by federal or state authorities or to seek variance from the standards and guidelines (e.g. alternate concentration limits)
- Construct "what-if" scenarios, for example, to compare the potential impact of remedial alternatives and to set priorities for corrective action
- Evaluate existing and new technologies for effective prevention, control, or mitigation of hazards and risks
- Develop a scientific framework for closing down or decommissioning facilities
- Address community public health and safety concerns and provide a consistent basis for expectations among different locations
- Provide a scientific basis for a corporate risk reduction and management program

BOX 6

(Source : Kolluru, 1996)

It is recommended that risk assessment be kept separate from risk management because the risk management involves consideration of risk data as well as political, social, technical, and economic issues for the development of alternative options for responding to current or potential hazards (NRC, 1983). Accordingly, NRC believes that

> "...risk assessment and risk management functions are analytically distinct, but in practice they do—and must—interact...." For example, to complete risk characterization, risk assessors must know what policy options are to be used to calculate alternative projected exposures, and new options may develop as the risk management process proceeds......Separation also could impair the risk manager's ability to obtain assessments that are timely and in a useful form..."

US experiences revealed that although it is the intent of the NRC recommendation to keep risk assessment separate from management issues in order to avoid prejudgment of the results by cost implications and value judgment (isolate science from politics and policy), it appears that the assessment and management phases suffer from this disjunction in practice.

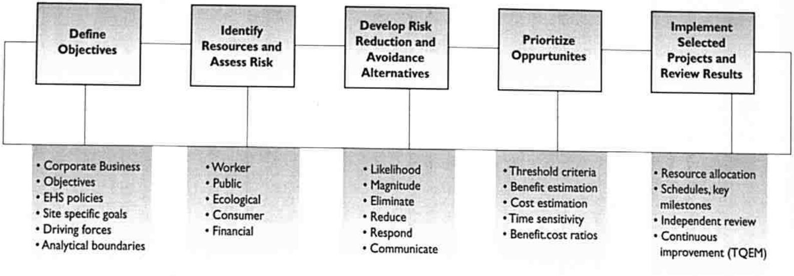

Figure 5: Risk Assessment and Management Integrated Framework (Source: Kolluru and Brooks, 1996)

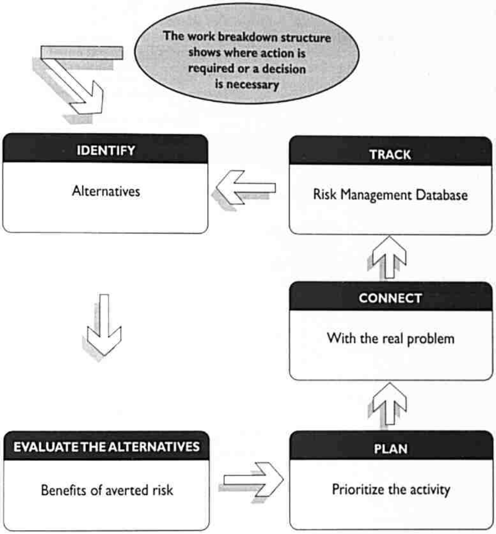

Figure 6: Components of EM Division Risk Assessment Process (Source: Kolluru and Brooks, 1996)

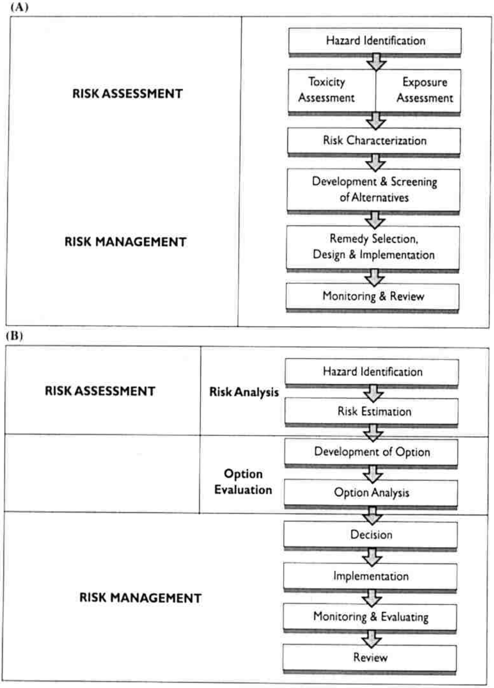

Figure 7: Generalised Risk Assessment and Management models: (A) American Model (Adopted from U.S. EPA, "Risk Assessment Guidance for Superfund", 1989). (B) Canadian Model (Health and Welfare Canada, "Health Risk Determination", 1989/90)

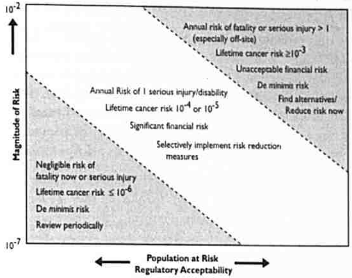

Figure 8: ***De Minimis and De Manifestis Risks - An Example***

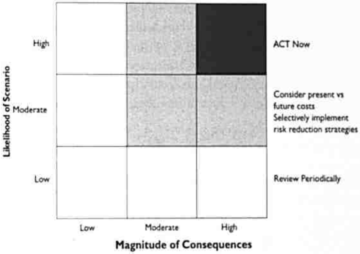

Figure 9: Risk Management Priorities - An Illustration

For example, in the Superfund remedial process, risk assessment is expected to provide a key link between remedial investigation (RI) of site and contaminant characterization, and the feasibility study (FS) of remedial action. Yet the site and the contaminant data collection and presentation are seldom adequate to devise a remedy. Furthermore, the long study phase and the time lag between study phase and action phase, changes in consultants and changes in EPA and state agency personnel worsened the process. In the Canadian situation, development of remedial options begins early in the process (refer to Canadian Risk Model, Figure 7), and the assessment and management phases are better integrated.

Risk Acceptability

Since risk estimates and probabilistic estimates could not provide a definitive answer to questions of 'how safe is safe?' and 'safe or unsafe?', an alternative answer is to rely upon the policy makers and risk managers to judge that a safe or acceptable level is based on many criteria including benefits versus risks. Based on zero-risk principle, no risk can be tolerated no matter how small and whatever the benefit to the society is. In reality, we do not and cannot live in a risk free world, as there is always background risk from natural sources, and a small risk would be seen preferable if a much larger risk could be avoided.

Figures 8 and 9 illustrate some simple ways of analyzing and prioritising the different types of risk for management action (Kolluru, 1996). Essentially they are based on *de minimis* and *de manifestis* principles. *De minimis* principle means that there are some levels of risk that are so trivial that they are not worth bothering about, whilst *de manifestis* concerns such an obvious risk that it must be controlled irrespective of cost. Risk of more than one in a thousand (10^{-3}) is in this latter category and will almost certainly trigger regulatory action. In practice, it is hard to define a *de minimis* level acceptable to an entire society. In the US and throughout much of the industrial world, regulatory authorities are understandably reluctant to be explicit about an acceptable risk. However, lifetime risk on the order of one in a million (10^{-6}) for the general public is often considered acceptable and is used by the USEPA, FDA and CPSC, although the origins of one in a million acceptable risk and the meaning of such a risk remains obscure. It has been argued that while there is value in having general 'bright lines' of acceptable risk levels, however, what is acceptable in a given situation will ultimately depend on the context and may have to be decided on a case-specific basis.

Issues and Trends

In the industrial world, the use of risk assessment in corporate risk management is becoming more and more prominent (Koluru and Brooks, 1996, Greeno and Wilson, 1996), as corporations may need to respond to regulatory concerns, want to redesign the risk profile (or environmental audit) of their operations, manage pollution-prevention efforts or develop long-term strategies based on risk management principles. In addition, corporate environmental, health and safety (EHS) policies are increasingly influenced by a number of non-traditional forces, often referred to as 'surrogate regulators' that impinge on risk issues. These include financial institutions, securities and exchange commissions, industrial associations, International Organization for Standardization (ISO), as well as the public.

In the past, responding to regulatory pressure has been the primary reason for corporate use of risk assessments, especially in supporting applications for discharge permits, to minimize potential liability in property transactions and to support development of new products. As a result, many companies have developed considerable expertise in risk assessment, while others turn to outside consultants. Currently, some firms are beginning to evaluate the 'risk profile' of their operations. This risk profile or an environmental audit emphasizes examining the potential risk to pose for the workers, plant neighbors, or the environment. The audit also examines the materials used, the products produced, and waste disposal practices as required by the ISO 14000 in their 'Environmental Audits', 'Life Cycle Assessment' and 'Environmental Labeling'.

It is realized that the use of these environmental audits in combination with risk assessment can help firms reduce liability, increase worker safety and improve community relations. As greater emphasis is placed on pollution prevention, rather than end-of-pipe control, this pollution prevention involves substitution of raw materials, changes in process or process equipment, improvement in plant housekeeping and many other strategies. Evidently, progressive firms are now beginning to use risk assessment to evaluate alternative pollution-prevention strategies, not only as one input to corporate risk management but also as part of their long-term strategic thinking. The thinking plays a role in product design, marketing, and accounting as well as the production side of the business. This approach requires proactive commitment on the part of management in return for strategic rewards.

The 'bright lines' concept entails attacking the biggest risks first, economic efficiency as embodied in cost-benefit-analysis doing the most good for most people, and environment equity. Such a concept mostly relies on estimates of risk from the risk assessment process as an important decision input. The decision making scheme relies on numerical estimates of acceptable risk, however, it ignores several other social and scientific factors that impinge on risk management. Furthermore, it removes the decision-making power from an accountable risk manager and places it with a policy analyst or legislator who designates the value of the 'bright lines'. In addition, because risk assessment is such an uncertain process, the use of a single estimates of risk for comparison with an acceptable risk level hides a great deal of relevant scientific information from the risk manager (Kolluru, 1996).

Another concept which is gaining momentum as a risk management theme is cost-benefit analysis and economic efficiency. It is believed that by addressing the risks with the lowest cost-benefit ratio or the highest benefit-cost ratio, we can make the most progress in reducing risk with limited resources. However, some environmentalists are concerned that hard-to-quantify factors such as the value of pristine wilderness or the reassurance provided to people by continually reducing pollution, may be ignored by cost-benefit analysis. Evidently, experiences faced by the industrialized countries have clearly shown that by ignoring cost-benefit analysis, a country might be spending a vastly different amount of money to address sources of a particular risk. In short, human judgement must always play a role in weighing alternative actions and competing interests. What risk managers need is good risk information that will allow them to do their job to ensure that a balanced decision is made.

Proposed Model for Risk Assessment and Risk Management in Malaysia

Ideally, the model should satisfy a number of basic requirements and it should be more 'focus' oriented in order to provide guidance and promote consistency in the undertaking. It has to be pragmatic and tailored to the local orientation, taking into consideration current drawbacks such as lack of personnel who have the vast experience necessary to address the issues. Moreover, risk assessment and risk management require that there should be some form of ongoing audit to appraise the effectiveness of the dissimilar measures taken to provide the necessary input. Perhaps to develop a pragmatic risk assessment and risk management methodology for Malaysia, both the US and Canadian models (Figure 7) could be utilized as the main basis, although some weaknesses are observed in those models.

For example, both models separate risk assessment from management issues, aiming to avoid prejudgment of the results by cost implications and value judgement. However, both phases do suffer from this disjunction in practice. The advantage of the Canadian model is that development of remedial options begins early in the process and the assessment and management phases are better integrated. In addition, as remediation requires 7 to 10 times more money than a study, the temporary advantage of postponement could be offset by higher cost, liability exposure, and negative image in the long term. Furthermore, the Canadian model that links hazards and risks directly with remedial options would be more effective in terms of lower costs and shorter time frames. In essence, the Canadian model is more practical. However, integration and simplification of both models could perhaps prove more appropriate to the Malaysian scenario. It should be stressed that the risk management of different phases of projects should not only address the physical sub-systems and their components, but also the need to integrate the action of personnel and their interaction with each sub-system.

It is recommended that the model be more pragmatic and 'focus' oriented. Essentially, the best option for the Malaysian model is to integrate probabilistic and quantitative risk assessment (Figure 10), human health and ecological risk assessment (Figure 11) and the practical sub-system risk assessment management model for civil, mechanical and structural engineering projects (Figure 12). The probabilistic and quantitative risk assessment framework emphasizes the identification of hazards, estimation of the likelihood of events occurring that would cause an accident, potential consequences of such an accident, and the likelihood that mitigation systems and the response measures would prevent or reduce the consequences. At least four dominant steps of safety hazard analysis, namely hazard identification, probability/frequency estimation, consequence analysis and risk determination and evaluation. While human health and ecological risk assessment, basically, a simplified modification and combination of both ecological/environmental risk assessment, health and safety risk assessment version adapted for US and Canada as discussed previously. The key components of the framework comprise data evaluation, problem formulation and hazard identification, toxicity assessment, ecological effects, exposure assessment and risk characterization. In principle, it should focus not only on ecological risk assessment, but also on human health risk assessment emphasizing long-term exposure to hazardous substances and related chronic health effects. Ecological risk assessment is far more complex and surrounded by even more uncertainty. On the other hand, the practical sub-system risk assessment/management deals with phases in the life cycle of a typical civil, mechanical and structural engineering project at which accidents and failures occur. These include site investigation, construction, commissioning, operating, maintenance and repair and finally decommissioning, demolition and removal. For the purpose of developing the model for

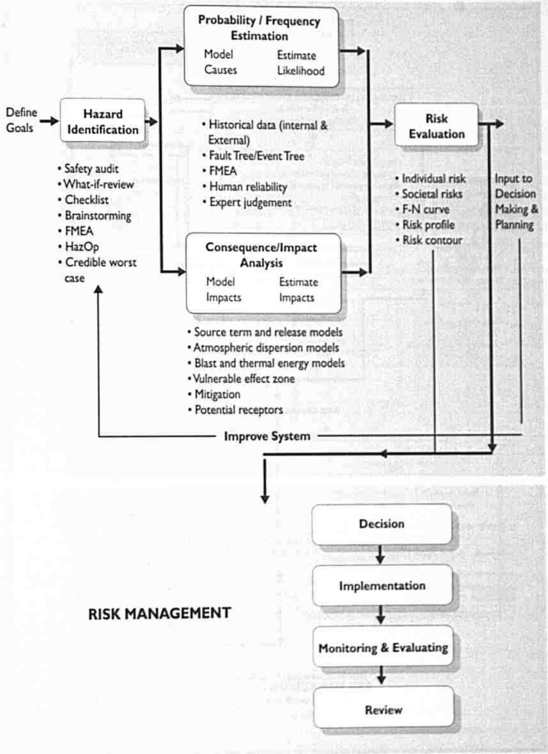

Figure 10: Probabilistic and Quantitative Risk Assessment Model (Adapted from Chemical Manufacturers Association, 'Evaluating Process Safety in the Chemical Industry', 1989)

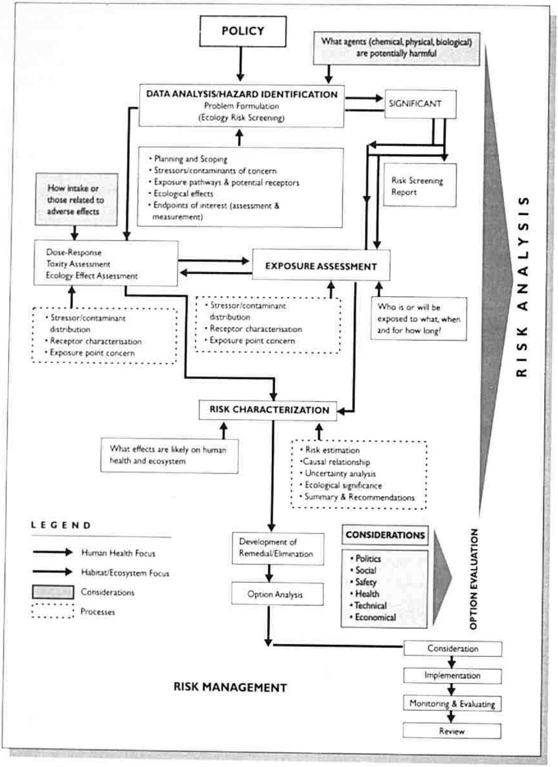

Figure 11: Human Health and Ecological Risk Assessment Model

(Source: Kolluru and Brooks, 1996)

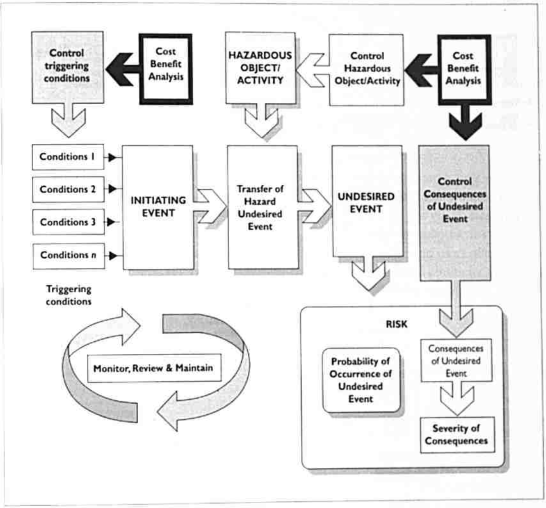

Figure 12: Basic Risk Management Model

(Source: Kolluru and Brooks, 1996)

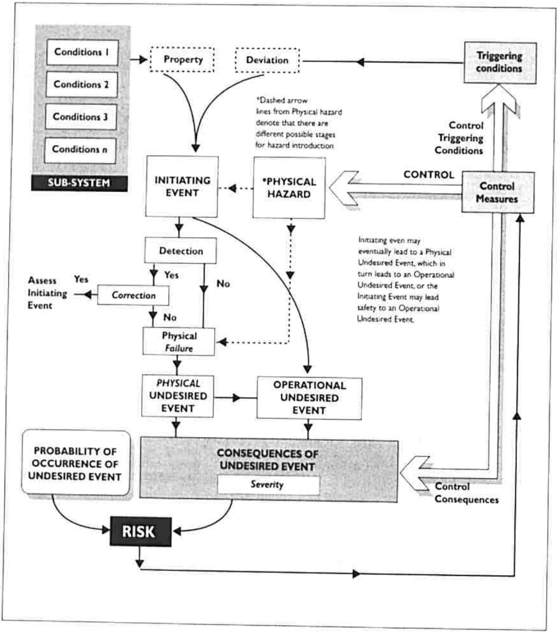

Figure 13 Overall Model of Sub-system Risk Management Approach

(Source: Kolluru and Brooks, 1996)

Malaysia, it is imperative to highlight some broad categories of circumstances which can lead to accidents and failures (Figure 12). The risk management of these sub-systems is a major part of overall project risk management comprising hazard identification and evaluation, risk assessment, and control measures (Figure 13). The results of the risk assessments of the sub-systems provide the components to enable risk assessors to control overall risk. In essence, this prototype risk management methodology should be sub-system oriented and examine the stages within each sub-system's life, covering conception through disposal, in order to evaluate the hazards and risks associated with its physical profile and operational characteristics.

CONCLUSION

ISO 14000 will affect every aspect of a company's management of its environmental responsibilities. It will help any organization address environmental issues in a systematic manner and thereby improve its environmental performance. The interactions between management decision, health, safety and ecological/environmental risk assessment and ecological research of environmental issues are complex. These processes (ecological risk assessment, health, safety and human health) require a basic understanding of hazard identification, exposure assessment, exposure-response assessment and risk characterization prior to the actual risk management practices. These components are not yet well understood by local scientists, managers and decision makers. Currently, ecology alone is not making a satisfactory contribution to the socially driven needs of the potential end users of ecological research. However, several frameworks established in the industrialized countries are worth examining with a view of modification to enable them to serve Malaysian needs.

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11 ENVIRONMENTAL LABELING

MUHAMAD AWANG

INTRODUCTION

The power of consumers to secure as much information as possible about the products they purchase and the insistence that they be supplied with 'environmentally preferable' goods forced manufacturers to provide comprehensive details relating to their products and packaging, and eventually labels started to appear on products and packages. Consequently, consumers became more confused and governments had to interfere in order to protect consumers from mislabeling and misadvertising. This phenomenon has occurred over the last decade in the western world, in particular in Europe and North America.

The subcommittee (SC) responsible for environmental labels and declarations is SC3, and is one of the six subcommittees that has been established by the TC 207. This subcommittee is further broken down into three working groups (WG). WG1 deals with General Principles for Practitioners, WG2 looks into Self-declared Claims, and WG3 prepares the General Principles for Environmental Labeling Programs. Figure 1 provide details on the ISO/TC 207 Subcommittees and Working Groups. As an example, SC1 which works on the Environmental Management Systems (EMS) Standards focuses on the basic elements needed to set up an effective environmental management system.

Essentially the eco-labeling program was started as a process that would advise consumers as to which products constituted an environmental choice. However, eco-labeling practice does influence exports and imports in that it is being used to unfairly discriminate against certain products through the adoption of local and regional environmental labels. These emerging environmental labels were interpreted differently by various consumers, and the issue of lack of uniformity was raised among trade proponents. Subsequently it was recommended that an ad hoc advisory group encourage International Organization of Standard (ISO) to develop standards in the field of environmental labeling. The objectives are to ensure that eco-labeling is accurate, verifiable and not misleading in order to prevent unwarranted claims, that it reduce marketplace confusion, restrictions, and barriers to international trade, and perhaps most importantly, that it increase the potential for market forces to stimulate environmental improvement in product delivery. Such standardized labels would better enable purchasers to make informed choices when buying goods and services.

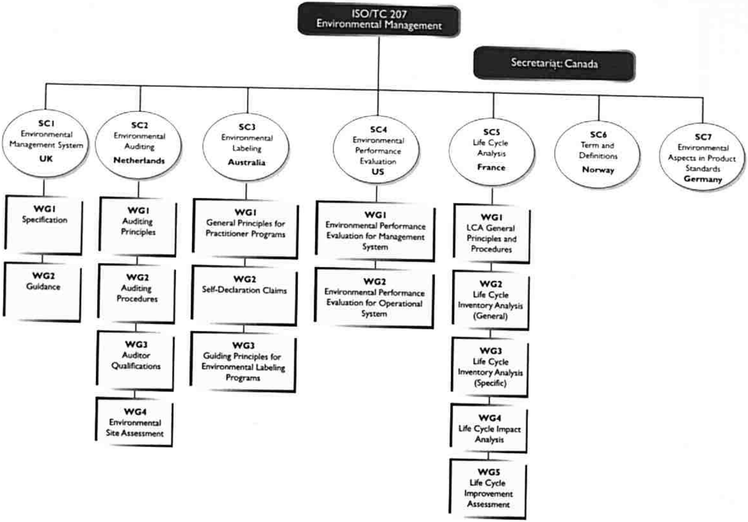

Figure 1 : ISO/TC 207 Subcommittees and Working Group (Tibor and Freldman, 1996)

DEFINITION AND TYPES OF LABELING

By definition (Husseini, 1997), environmental labeling is any environmental declaration that describes or implies, by whatever means, the effects of the life cycle of a product or service on the environment. It might be in the form of statements, symbols or graphics on products or packaging, literature or technical bulletins, advertising or any form of publicity.

Three types of labeling have been established. Type I, is a third-party certified 'eco-label'. Such certification is granted by the practitioner seal program which is sponsored by a government or operated privately. The seal programs require manufactures to meet a minimum or a 'threshold' in order to receive the seal of the program. Type II, is a self-declared environmental claim, without independent third party certification, with the condition that the manufacturers may place the labels, provided they follow specific requirements set forth in the ISO 14021 standard. Type III, conveys quantitative information of a product's environmental performance that is derived from life cycle inventory data or life cycle assessment.

ISSUES ON WORLD TRADE AND POLITICS

As the basic perception of and approaches to labeling differ among countries and regions, and its development is subjected to pressures from various stakeholders, obviously, the influence of politics and world trade provides significant impacts on the process as a whole. North Americans appear to be more flexible with manufacturers by encouraging them to self-regulate their action, provided self-regulation meets the overall goals set by the government, whilst Europeans place more emphasis on prescriptive requirements. Demands imposed by the stakeholders, consumers, and environmentalists insisting upon influencing the process, emphasizing honesty and clarity of the labels and that labeling should lead to the protection of the environment, add further to the complexity of the equation. In addition, developing countries demand the labels be achievable in order to maintain or increase their exports to industrialized countries and giant corporations want labels that will be internationally applicable.

Other issues include setting an objective related to environmental improvement which may cause problems for industry if the industry is challenged at some stage to prove that they are achieving continuous environmental improvement. On the other hand, if environmental improvement (minimization of environmental impacts) is not going to be in the objective statement, there is not much point in developing these standards. In terms of international trade and non-tariff trade barriers, it appears that some countries have very strong Type I programs that do not particularly subscribe to prescriptive language. Such a situation would restrict their freedom in setting criteria for their Type I guidelines.

WHY DO WE NEED ENVIRONMENTAL LABELING STANDARDS?

Essentially labeling programs are needed to harmonize national and regional standards worldwide to derive at least five benefits which vary in their importance depending on the stakeholder concerned. These benefits may be summarized as follows:

1. To minimize mistrust and confusion among consumers/purchasers due to the proliferation of claims and labels in the marketplace

2. To improve environmental performance of a product through the reduction of environmental burdens associated with its life cycle impacts, including the manufacturing, use, and disposal of a product or packaging

3. To enhance international trade by reducing or limiting the negative trade effects of regional labeling by replacing them with ISO-developed environmental labeling standards, thus ensuring that environmental labels do not act as non-tariff trade barriers as the world moves closer towards open borders and free trade

4. To strengthen voluntary 'self-regulating' standardization as manufacturers realize that consumer purchasing power or 'market forces' are as effective as regulation in the field of environmental labeling

5. To allow consumers/purchasers have more confidence in making choices as the ISO labeling standards ensure that all information is accurate and non-deceptive

Basically, the adoption of the ISO standards will not only assist in harmonizing the practitioner Type I programs, but also in enhancing the effort towards reducing trade barriers and encouraging manufacturers to use accurate, verifiable, and non-deceptive claims.

SCOPE

As mentioned earlier, Standardization of Environmental Labeling is under the responsibility of SC3 which covers Type I third party certification practitioner seal program, Type III programs, and first party practices (self-declared environmental claims) and also advertising, environmental statements and reports.

There are three working groups (WGs) established under SC3 (Box 1). Working Group 1 (WG1) - Guiding Principles of Environmental Labeling Practitioner Programs and Systems is involved in developing two standards, ISO 14024 (Type 1 Labeling) and ISO 14025 (for Type III Labeling). Working Group 2 (WG2) - Self-Declared Environmental Claims- Type II Labeling) is working on three items which include terms and definitions, symbols, and testing and verification methods. Working Group 3 (WG3) - Basic Principles for All Environmental Labeling is involved in developing a general principle standard that applies to all environmental labeling and claims.

WG 1:

ISO 14024: Environmental Labels and Declarations - Type I Environmental Labeling encompasses guiding principles and procedures for multiple criteria-based, practitioner-operated environmental labeling programs that apply to all labeling programs worldwide. The established basic principles (based on life cycle considerations, compliance with regulations, transparency, consultation and functional characteristics) will be utilized in the programs in order to enhance their scheme. It addresses multiple criteria-based environmental impacts associated with the product as well as describing the procedures for the selection of the product categories, including selection matrices and qualitative and quantitative indices. It also addresses certification procedures, licensing, the assessment of compliance and conformity, monitoring, and final granting of the label (program seal).

ISO 14025: Environmental Labels and Declarations - Type III Environmental Declarations is a quantitative information label that requires life-cycle inventory data which outlines the environmental loading associated with the various stages of the life cycle of the product or packaging (i.e. from cradle-to-grave concept). As the concept itself is scientifically based, it provides consumer satisfaction as it relays more comprehensive information. In terms of its execution however, it is rather challenging as the life cycle assessment (SC5) is still an emerging science, particularly in the life cycle impact assessment (LCIA) which is still in its infancy. Consequently the results presented may be of dubious quality. It is anticipated that the development of Type III Standards will require at least three to five more years, as the task force (based in Sweden) will have to work with international experts to formulate methods that are credible and acceptable to consumers, industry, and international trade.

WG 2:

ISO 14021: Environmental Labels and Declarations - Type II Environmental Labeling - Self-Declared Environmental Claims involve claims in the form of statements, symbols, or graphics on products or packaging made without independent third-party certification, by manufacturers, importers, distributors, retailers, or anyone else likely to benefit from such claims. The claims can also be in the form of product literature, technical bulletins, advertizing, publicity, or telemarketing emphasizing on recyclable or biodegradable materials, recovered energy, and water conservation that normally addresses environmental aspects of products and packaging.

The first standard called 'The ISO14021' comprises terms to be used in making claims. Basically it has two major sections : 'General Guidelines' that cover all the claims and 'Specific Terms' that encompass the most commonly used terms such as 'recyclable', 'recycle content', 'biodegradable', "recovered energy' and 'water conserving'. A second standard 'The ISO 14022', comprising environmental labeling symbols, addresses the most common symbols that correspond to the terms and definitions. Obviously, the Mobius loop is one of the symbols which is most commonly used. The third standard, 'ISO 14023' consists of testing and verification methodologies. It describes methods of testing and verification that can be used to prove and verify that self-declaration environmental claims are duly implemented and meet the general requirements such as being non-deceptive, clear, accurate, etc. The standards include general principles that are common to specific environmental claims and provision inherent to such claims.

WG 3:

Environmental Labels and Declarations - ISO 14020 General Principles of All Environmental Labels and Declarations gives general guidelines applicable to all types of labeling.

BOX 1: Working Groups Under TC 207/SC 3 Environmental Labeling

(Source: Husseini, 1997)

KEY PRINCIPLES OF ISO 14020

1. **Environmental labels/declarations shall be accurate, verifiable, relevant, and non-deceptive.** This principle outlines the need to reach consumers and purchasers to give them reliable, verifiable information. Requesting that the information be relevant is an assurance that only nontrivial environmental attributes will be claimed. This information should be clear enough not to suggest specific environmental attributes that do not exist, thus misleading the consumer into purchasing the product.

2. **Procedures and requirements for environmental labels/declarations shall not be prepared, adopted or applied with a view to, or with the effect of creating unnecessary obstacles to international trade.** This is the principle that has been so difficult to develop. It is meant to be in line with the activities of General Agreement on Tariff and Trade (GATT)and the new World Trade Organisation (WTO). The issue is still being debated at the work group, subcommittee, and full TC 207 levels. It is important that labeling standards should not 'permit' the creation of non-tariff trade barriers through specific requirements that discriminate against imported foreign products.

3. **Environmental labels/declarations shall be based on scientific methodology that is sufficiently thorough and comprehensive to support the claim and that produces results that are accurate and reproducible.** This principle is very important since it outlines the basis by which claims and labels may be made. Scientific methodology includes life cycle considerations, databases, risk assessment, and full cost accounting. Reproducibility of these methods is in line with all scientifically based tests. It also ensures verification.

4. **The development of environmental labels/declarations should, wherever appropriate, take into consideration the life cycle of the product or service.** Again, this principle emphasizes life cycle considerations, particularly identifying the potential of a particular life cycle impact to increase while another is decreased.

5. **Any administrative requirements of information demands related to environmental labels/declarations shall be limited to those necessary to establish conformance with applicable criteria and standards of the labels/declarations.** This principle addresses the requirement of relevancy of the claims to the environmental attributes. It also emphasizes that the involvement of companies, large or small, should not be hindered by unreasonable costs, administrative complexities and requirements, or demands.

6. **Information on the environmental aspects of products and services relevant to an environmental label/declaration shall be available to purchasers or potential purchasers from the party making the environmental label/declaration.** This is an important addition to the draft standard. It establishes the right of purchasers to know. They need accurate information to make an informed choice. This also puts the responsibility on the parties making the claim to research the information and

ensure its credibility. Information provided also has to be reasonably understandable by the general purchasing population.

7. **Information concerning the procedure and methodology used to support environmental labels/declarations shall be available and provided upon request to all interested parties.** This principle ensures that unsubstantiated claims and half-truths are not presented. Information available must include underlying principles, assumptions, and boundary conditions. This principle is also in line with other ISO 14000 standards.

The situation becomes more serious as some environmental groups indicate, understandably, a preference for the protection of the environment in lieu of conformance to freer trade. Since ISO standards are developed by consensus, SC3 hopes to develop a final text for this principle that is both in line with the WTO international agreements and gives allowance to environmental concerns.

ISO 14024 TYPE I ENVIRONMENTAL LABELING

The ISO 14024 draft (FDIS) contains guiding principles for selecting product categories and setting product environmental criteria and product performance characteristics and certification for multiple criteria-based, practitioner-operated, environmental labeling seal programs. "Multiple criteria" is emphasized here as single criteria environmental claims do not normally create an overall environmental benefit since life cycle considerations are not included.

Introduction

The introduction explains that the label (seal) of Type I labeling schemes identifies products that have been selected as "a preferred environmental choice" within a particular product category. It also states that Type I labeling programs are voluntary, can be operated by public or private agencies, and may be national, regional, or international. Certification (or awarding of the label) is different from certification of conformity to ISO standards.

Objective

The objective states clearly that the overall goal of Type I labeling is to contribute to a reduction in the environmental burdens and impacts associated with products. This is achieved by identifying those products that claim an overall environmental preference. The point is that the seal is still a claim of overall environmental preference, not a ruling of overall environmental performance.

Major Definitions

1. *Type I environmental labeling program.* A voluntary, multiple criteria-based, practitioner program that awards labels claiming the overall environmental preference of a product within a particular category based on life cycle considerations

2. *Product.* Any good or service (includes packaging)
3. *Product category.* A group of products that have equivalent functions (Water-based paint would be considered as a category)
4. *Product function characteristics.* Environmental requirements that the product shall meet to be awarded an environmental label
5. *Practitioner.* A third-party body (government or private agencies included) that operates an environmental labeling program

Key Guiding Principles

The standard emphasizes the following guiding principles:

1. The program should be voluntary in nature and implementation
2. It should assess only those products that are in compliance with regulations

Life cycle considerations apply to extraction of resources, manufacturing, distribution, use, and disposal. Considerations will be assessed relevant to cross-media environmental indicators. Departure from this comprehensive approach must be clearly stated and justified.

Selectivity is an important principle. Product environmental criteria must be established to 'differentiate' leading products from others in product categories. This will be based on a significant difference in total environmental impact achieved through compliance.

It is understood and taken into account that assessment methodologies may vary in level of precision and accuracy in evaluating those products that satisfy the criteria. Arbitrary cut-off levels should not be established, that is, levels should not be designed to exclude a predetermined percentage of products from qualifying for the level. In other words, a threshold set to accept 20 percent of the top performers may be challenged. In practice, it is difficult to comply with this requirement. Threshold levels are normally set through political and subjective decisions based on background information. It is hoped that this requirement will influence existing programs to use technical and scientific rather than political decision making.

Product environmental criteria are based on life cycle considerations set to levels attainable within a predetermined period (not targets). They shall be reviewed at the end of that period.

Products should meet their intended purpose (performance). This is achieved through meeting international and regional standards.

The process should also be transparent, and consultation with stakeholders is a requirement. Transparency includes the selection and award procedures, the certification, the periodic review requirements, the funding sources, the resting and verification methods and compliance verification.

The programs must not create unnecessary trade restrictive requirements. It shall be open to all potential parties that wish to apply. The program criteria selection must be based on scientific methodologies. Conflicts of interest shall be avoided. Fees should be reasonable and based on program costs. Confidentiality of information from applicants must be ensured.

Procedures for Establishing Program Requirements

The selection of product categories and the development of product environmental criteria is an iterative process that needs to be reassessed and revisited. Stakeholders should be consulted and new technological and scientific methodologies included.

The selection of product categories is based on an initial review, consultation with stakeholders, market surveys, assessment of environmental performance of products, the need for environmental improvement within that product category, feasibility of product categories and the equivalence of performance, their functional characteristics, the availability of data (including life cycle consideration data), and the current national and international regulatory agreements.

Once the proposal for a product category is submitted, the selection of product environmental criteria begins. Life cycle considerations, based on scientific methodologies, are included in an assessment matrix. This comprises the 'stages in the life cycle' (which includes extraction of resources, manufacturing, use, and disposal) and the corresponding environmental loading (inputs and outputs). These include energy (renewable and nonrenewable), resources (renewable and nonrenewable), and emissions to water, air, and soil. Relevant local, regional, and global issues should be also taken into account.

The toughest challenge is the identification of the relevant areas for reduction of environmental burdens. This is done through the use of qualitative and quantitative indices, including weighting factors. The use of such weighting factors must be clearly justified.

The practitioner then determines the best criteria and assigns values to them. Minimum values and threshold levels are set. A scale point system may be used. Test methods are then determined and outlined. The selection of product functional characteristics is set. This includes performance levels. Since the process is transparent, reporting is an important element. Modifications to the process should be clear and carried out with stakeholder consultations.

The Certification Process

Compliance with the general rules and the technical specific requirements (product environmental criteria and function characteristics) must be met. Supporting documentation is required with each application.

The practitioner should also make the necessary documentation available to the applicant, outlining the basic elements of the program and the methods by which the assessment is to be made. Upon granting of the label seal, the program shall monitor the marketplace and assess any deviation from the requirements. The licensee should also report any such deviations.

ISO 14021 TYPE II ENVIRONMENTAL LABELING

ISO 14021 addresses Type II labeling. Self-declared environmental claims (SDEC) may be made by manufacturers, importers, retailers, or anyone else likely to benefit from such claims. Claims can take the form of statements, symbols, product literature, advertizing, telemarketing, and so on. ISO 14021 is the first in a series of four standards. ISO 14021 covers terms and definitions, ISO 14022 covers symbols, and ISO 14023 covers testing and verifications, whilst ISO 14024 emphasizes that the standard establishes 'general' guidelines regarding claims in relation to the supply of products and services. It also defines and sets rules for the use of specific terms. The scope emphasizes that the standard does not override legally required information supplied through labels of claims. It also states that the issue of sustainability is complex, and therefore a claim denoting it is not appropriate at this time.

Objective

The objective statement suggests that the objective of ISO 14021 is to contribute to a reduction in the environmental burdens and impacts associated with the consumption of products and services. Anticipated benefits comprise accurate, verifiable, non-deceptive environmental claims, the stimulation of environmental improvement through market forces potential and prevention of unwarranted claims, enabling consumers to make better informed purchasing choices.

Major Definitions

1. *Environmental claim.* Any environmental declaration that describes or implies, by whatever means, the effects that the raw material extraction, production, distribution, use, or disposal of a product or service has on the environment. This applies to effects that are local, regional, or global, and to the environment that an individual lives in, affects, or is affected by.
2. *Self-declared environmental claim (SDEC).* An environmental claim that is made, without independent third-party certification, by manufacturers, importers, distributors, retailers or anyone else likely to benefit from such a claim.
3. *Package/packaging.* A material or item that is used to protect or contain a product during transportation, storage, or marketing. A package can also be a material or item that is physically attached to, or included with, a product or its container for the purpose of marketing the product or communicating information about the product.
4. *Qualified environmental claim.* An environmental claim that is accompanied by a statement that describes the limits of the claim.

Some Elements in the General Guidelines for Terms and Definitions in SDEC

In addition to ensuring that they meet the elements of ISO 14020, SDECs are expected to have the following attributes:

1. Accurate
2. Non-deceptive
3. Substantiated
4. Verifiable
5. Relevant
6. Used only in an appropriate context or setting
7. Specific and clear as to what particular environmental attribute the claim relates to
8. Unlikely to result in misinterpretation
9. Meaningful in relation to the overall environmental impact of the product or service during its life cycle
10. Presented in a manner that clearly indicates that the environmental claim and explanatory statement be read together
11. Not presented in a manner that implies that the claim is endorsed or certified by an independent third-part organization when it has not been

SDECs must specify the environmental improvement or attribute of the product or service. They must not, either directly or by implication, suggest an environmental improvement that does not exist, nor shall they exaggerate the environmental benefit of an attribute of the product or service to which the claim refers. Unqualified environmental claims should be made only if they are valid in all foreseeable circumstances with no qualifications.

Any SDEC that involves a comparative assertion of environmental superiority (this term is used in life cycle assessment studies comparing one product to another and suggesting its overall environmental superiority) based on improvement shall be specific, valid, and make clear the basis for the comparison.

In particular, the SDEC must be relevant in terms of how recently any improvement was made. If comparisons are made, they should be in accordance with a published standard or recognized test method and/or comparable products or services serving similar functions supplied by the same or another producer.

SDECs must not be presented in a manner that might lead purchasers to believe that the claim is based on a recent product or process modification if this is untrue. SDECs should also be relevant to the life cycle of the product. SDECs must clarify to the purchaser whether the claim applies to the product or packaging.

SDECs should not be made if the claim is based on the absence of an ingredient that was never there in the first place. In other words, if a cleaner never had ozone depleting substances, such as CFCs, the manufacturer should not make a claim for marketing purposes only. SDECs must also be relevant to the geographic area in which the corresponding benefit occurs.

This issue has been the source of debate in WG2. Exporting countries raised concerns that it would be not practical for them to claim specific SDECs if these do not occur in their exporting country. For example, locally produced products that conserve water in their manufacture in a country where water is scarce may be able to put a SDEC on their products, while foreign products that do not conserve water in their manufacture in a country where water is abundant may not make that claim. Finally, SDECs should only be made for actual benefits, not potential ones.

Verification of SDECs

Though ISO 14021 references ISO 14023 for testing and verification of SDECs, it states that verification methodologies shall be reproducible, repeatable, and scientifically sound.

SOME SPECIFIC TERMS IN THE ISO 14021 DRAFT (DIS)

The following are specific terms defined in ISO 14021. Note that the word qualification in the following terms means the conditions under which the claim can be used. That is, it is an explanatory statement that describes the limits of the claim. In general, claims such as 'environmentally friendly', 'safe', 'beneficial,' and so on, are not permitted.

Recyclable

A characteristic of a product, packaging, or component thereof that can be diverted from the waste stream through available processes and programs and can be collected, processed, and returned to use in the form of raw materials or products.

Qualifications (conditions) for the use of the term recyclable. A qualified claim of recyclability has to be used if collection or drop-off facilities for recycling the product or packaging are not conveniently available to a reasonable portion of the population where the product is sold. If such facilities are not conveniently available to a reasonable portion of the population, explanatory statements have to be made to convey the limited availability of collection facilities. Explanatory statements that do not convey the limited availability of collection facilities, with phrases such as 'Recyclable where facilities exist', are not adequate. Where only the package, or only an identifiable component of the product or package, is recyclable, the claim must specifically identify what is recyclable. Where the claim appears on the package but refers only to the product, the claim shall specifically identify what is recyclable.

Recycled Content/Material

This refers to the proportion, by mass, of recycled material in a product or package. Recycled material is that which would have otherwise been disposed of as waste but has instead been collected and reclaimed as a material input, in lieu of new primary material, in the manufacture of products. Only post-consumer and preconsumer recycled materials may be considered as recycled content.

Pre-consumer material. That which is diverted from the waste stream during a manufacturing process. Excluded is reutilization of materials such as reworked, reground, or scrap generated in a process and capable of being reclaimed within the same process that generated it.

Post-consumer material. That material which is generated by commercial, industrial, and institutional facilities, or households, which can no longer be used for its intended purpose. This includes returns of material from the distribution chain.

Qualification (conditions) for the use of the term recycled content. If the claim applies to both the product and its package, the percentage recycled content for each shall be specified independently.

Reduced Resource Use

A reduction in the amount of material, energy, or water used to produce or distribute a product or package or specified component thereof.

Qualification (conditions) for the use of the term reduced use. No unqualified reduced resource use claims shall be made. As 'reduced resource use' is a comparative claim, life cycle considerations for comparative assertions shall be met.

Recovered Energy

Energy recovered from material that would have been disposed of as waste but has instead been collected and converted through specific processes and is used to produce products or services.

Reducing Solid Waste

Reduction in the quantity of material (mass) entering the solid waste stream due to a change in the product, process, or packaging.

Qualification (conditions) for the use of the term solid waste reduction. No unqualified claims regarding waste reduction shall be made. Calculations of process waste reduction must not include in-process reutilization of materials such as reworked, reground, or scrap materials generated within the plant and capable of being reused within the process that generated them.

Reduced Energy Consumption

Reduced energy consumption associated with the use of a product compared with functionally equivalent products that perform the same task.

Qualifications (conditions) for the use of the term energy-efficient/energy-conserving/energy-saving. No unqualified claims regarding energy reduction may be made. Energy-efficient/energy-conserving/energy-saving are comparative claims.

Reduced Water Consumption

Reduced water consumption associated with the use of a product compared with functionally equivalent products or processes providing a generally equivalent service.

Qualification (conditions) for the use of the term water-efficient/water-conserving/ water-saving. No unqualified claims regarding water efficiency/reduction may be made unless a performance test method is identified. Water-efficient/water-conserving/water-saving are comparative claims.

Extended-life Product

A product designed to provide prolonged use, based on either improved durability or an upgradability feature, that results in reduced resource use or reduced waste.

Qualifications (conditions) for the use of the term extended-life product. No unqualified claim of extended life may be made. Extended-life product is a comparative claim. A claim of extended life for a product should be based on overall life cycle environmental considerations. Other conditions apply.

Reusable

A characteristic of an item that has been conceived and designed to accomplish within its life cycle a certain number of trips or rotations for the same purpose for which it was conceived.

Refillable

A characteristic of an item that can be filled with the same or similar product more than once, in its original form, and without additional processing except for specified requirements such as cleaning and washing.

Qualifications (conditions) for the use of the terms reusable/refillable. No product or package must be claimed to be reusable or refillable unless the item can be reused/refilled for its original purpose. Similar conditions to recyclable apply.

Designed for Disassembly

A characteristic of a product's design that enables the product to be taken apart at the end of its useful life and the parts reused or recycled.

Qualification (conditions) for the use of the term designed for disassembly. All claims that a product is designed for disassembly must be clearly qualified so that the claim specifies whether the disassembly is to be done by the purchaser or whether it is to be returned for disassembly by specialists. The claim shall also identify the environmental benefits of disassembling the product. Other conditions apply.

Compostable

A product, package, or element thereof is compostable if, through an available, managed composting procedure, biodegradation occurs and the material is converted into a relatively homogenous and stable humus-like substance.

Qualifications (conditions) for the use of the term compostable. A compostability claim must not be made for a product or package or a component of a product or package that negatively affects the overall value of the compost as soil amendment. Likewise, if it releases substances uncharacteristic of the process in concentrations toxic to humans or the environment at any point during decomposition or subsequent use. Other conditions similar to those for Recyclable apply.

Degradable/Biodegradable/Photodegradable

A characteristic of a product or packaging that allows it to break down so that the resulting materials can be easily assimilated into the environment. Degradability is a function of susceptibility to changes in chemical structure that result in molecular weight reduction. Consequent changes in physical/mechanical properties lead to the disintegration of the product/material. For purposes of the following qualifications, unless otherwise qualified, the term degradable refers to all types of degradability.

Qualifications (conditions) for the use of the term degradable/ biodegradable/ photodegradable. Claims of degradability must only be made in relation to a specific test method, end point, and period of time to reach the endpoint. They must be relevant to the circumstances in which the product or package is likely to be disposedof.

ENVIRONMENTAL LABELING - SELF-DECLARED ENVIRONMENTAL ISO 14022 CLAIMS - SYMBOLS

ISO 14022 complements ISO 14021 on Type II Labeling. Self-declaration environmental symbols may also be used by manufacturers, importers, retailers, or anyone else likely to benefit from such a claim.

Since the draft standard complements the terms and definitions standard ISO 14021, it has adopted the same text in the introductory clauses, such as the introduction, objective, definitions, and general guidelines. These sections will not be repeated in the following summary. WG2 has briefly discussed combining ISO 14021 and ISO 14022. No decision has been made regarding this issue.

Definitions

1. *Environmental symbol.* Any symbol in the public domain that conveys or implies or is likely to be interpreted as making an environmental claim.

2. *Qualified environmental symbol.* An environmental symbol that is accompanied by an explanatory statement. For example, the **portrayal of natural objects** (such as trees or animals) that are likely to be interpreted as making an environmental symbol shall not be used unless the requirements of ISO 14020 and ISO 14021 are met.

3. *Accompanying text.* Environmental symbols for self-declaration environmental claims shall be accompanied by explanatory text if the symbol alone is likely to result in misinterpretation.

4. *Non-environmental claims.* Text, numbers, or symbols can be used in addition to environmental symbols to communicate information such as material identification, disposal instructions, or hazard warnings.

Text, numbers, or symbols used for non-environmental claim purposes should

1. not be used in a manner that is likely to be misconstrued as making an environmental claim, for example, text, numbers, or symbols used for material identification should not imply recyclability,
2. not be modified to relate the symbol to a specific brand, company, or corporate position,
3. not be used on a product or service to express conformance to an environmental management system, and
4. be simple, easily reproducible, and capable of being positioned and sized to suit the product range to which the symbol is likely to be applied.

Environmental symbols for one type of environmental claim should be unique and easily distinguishable from other symbols, including symbols for other environmental claims.

Explanatory text accompanying a symbol shall be governed by the general principles and the applicable specific requirements in ISO 14021.

Specific Symbols

Mobius Loop Symbol (chasing arrows)

The Mobius loop is a graphical symbol in the shape of three chasing arrows forming a triangle. The draft standard includes the following guidance about the use of the Mobius loop:

1. It may be used in outline form, in reverse print, or as a solid symbol. There should however, be enough contrast so that the symbol is clear and distinguishable.
2. It may be used to convey information regarding either recyclability or recycled content. Its use is limited exclusively to information regarding recyclability or recycled content. It shall not be used in any other environmental context.
3. It shall always be accompanied by explanatory text to ensure that the consumer, purchaser, or user is not misled. The explanatory text's purpose is to inform the consumer, purchaser, or user whether the symbol represents recyclability or recycled content. The text shall be immediately adjacent to, normally below, the symbol.

4. It is optional when a recyclable or recycled content claim is made. If the symbol is used, it shall conform to all of the requirements of the standard.
5. It may apply to the product or to the package. Whether it applies to the product or package should be made clear to the purchaser.
6. Its design shall meet the graphic requirements of ISO 7000-1135. If the Mobius loop is used, the requirements of ISO 14020 and ISO 14021 shall be met.
7. It may have additional accompanying text identifying material type.
8. If used as a recycled content symbol, it shall include the percentage recycled content within the loop.

CONCLUSION

Environmental labeling will continue to gain more weight compared to traditional factors such as quality and cost, as international trade becomes a major factor in planning and developing new products. Pressures from economic players including consumers and environmental groups, as well as better awareness of the impacts of product's life cycle on the environment, ensures that environmental labeling will become a major consideration in world trade. In addition, the growing acceptance of ISO 9000 certification all over the world will provide the impetus for and upsurge in ISO 14001 registration for environmental management systems that will itself spur interest in environmental labeling standards. As trading blocks unite and become a global organization, voluntary standards such as the ISO environmental labeling standards will be an ideal replacement for existing local standards or will be adopted as regulations in countries which have yet to define their own standards.

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12 THE ISO 14020 SERIES AND ITS IMPLICATIONS ON TRADE

KUN MO LEE

Economic instruments such as extended producer responsibility (EPR) and green purchasing network (GPN) are conducive to environmentally sound and sustainable development in our society. The implementation of EPR and GPN requires tools such as environmental labels and declarations (EL). EL has been used to encourage the demand for and supply of those products that cause less stress on the environment, thereby stimulating the potential for market-driven continuous environmental improvement. However, EL may confuse consumers and act as potential trade barriers. Harmonization of EL by the International Organization for Standardization (ISO) resulted in EL standards termed the ISO 14020 series. The contents of the ISO 14020 series and its implications on the market are discussed.

Most of the environmental problems we have today result from industrialization and its associated activities. Resources consumption as well as environmental emissions originating from the life cycle of a product - raw material acquisition, manufacturing, use and disposal - can jeopardize environmentally sound and sustainable development in our society.

Environmental laws and regulations, which may confuse consumers and act as potential trade barriers, are being promulgated in many parts of the world. Extended Producer Responsibility (EPR) is an emerging strategy being used in Organization for Economic Cooperation and Development (OECD) countries to achieve waste prevention and reduction, and increased use of recycled materials in production, among others (OECD, 1996). EPR extends the responsibilities assigned to the producers and distributors in the past to include responsibilities for the management of the product at the after-use stage. Ten OECD governments as of 1996 have adopted national legislation that imposes EPR requirements on producers of such products as electric/electronic products, packaging, automobiles, waste paper, and motor oils (OECD, 1996).

The Blue Angel in Germany, the White Swan in the Nordic countries, the EcoMark in Japan, the Environmental Labeling Mark in Korea and the Environmental Choice in Canada, among others, signify and encourage the use of environmentally friendly products. These so called environmental labeling programs, though voluntary in nature, can exert significant impact on the market if the environmental awareness of the consumer is high. Hence, these voluntary systems may act as potential technical barriers to trade.

Recently, texts and symbols emphasizing the environmental aspects of a product or service have been more used frequently in product advertisements. The purpose of these types of advertisements is to increase the market share by promoting the environmental friendliness of a product to the environmentally conscious consumers.

The environmental claims made by a company (self-declared environmental claims), however, are often non-verifiable. This in turn confuses the consumer. Since these unfounded environmental claims are counter-productive to environmental consideration, regulations regarding the use of environmental terms and symbols have been enforced in many parts of the world. Such regulations are not only applicable to domestic products but also to imported products. Hence these regulations also have the potential of being used as trade barriers.

The World Trade Organization (WTO) recognizes that environment related regulations and practices and environmental terms/symbols can be potential trade barriers. In June 1995, the committee on Technical Barriers to Trade (TBT) in the WTO officially urged the International Organization for Standardization (ISO) / Technical Committee (TC 207) to complete the standardization of the environmental labeling program and self-declared environmental claims as soon as possible. One of four TBT principles includes the standardization of environmental standards to promote international trade and to maintain fair trade practices.

All these reasons and trends provide the background for the standardization work undertaken by the ISO in the field of the environmental labeling. The following sections will describe the contents of the Environmental Labels and Declarations (EL) standards, as well as the major standardization activities.

The subcommittee (SC) responsible for environmental labeling standardization under the TC207 is SC3. The organizational chart of SC3 and assigned tasks are shown in Figure 1.

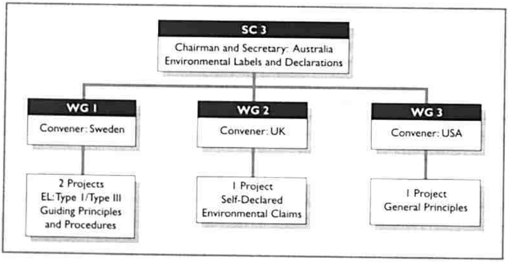

Figure 1 : The SC3 Organizational Chart with Working Groups (WG) and Assigned Tasks

The SC3 coined new terms, Type I and Type II EL, to differentiate a third party operated certification scheme called eco-labeling from self-declared environmental claims. Type I EL represents the eco-labeling and Type II, the company's self-declared environmental claims. When a new third party scheme was brought into the SC3 for standardization, a new term, Type III EL, was coined.

The overall goal of environmental labels and declarations is to encourage the demand for and supply of those products and services that cause less stress on the environment, thereby stimulating the potential for market-driven continuous environmental improvement (ISO a, 1997). Manufacturers, importers and distributors are interested in using the environmental labels and declarations for the marketing of their products. However, the use of environmental labels and declarations shall be made through communication of verifiable, accurate, and not misleading information on environmental aspects of products and services (ISO a, 1997).

WORKING GROUP 1 TASKS

Two separate tasks were assigned to this working group. One task was to standardize the Type I EL program (ISO 14024) known as eco-labeling. The main emphasis of this standardization is to establish basic requirements and procedures for eco-labeling, such as the selection of product category and environmental criteria. The other task was the standardization of the Type III environmental declaration program. The feature of this program is to identify the environmental burdens of a product throughout its life cycle. Both programs are similar in that they are operated by third parties; however, the content of each program is completely different.

The first Type I EL program that appeared in the world is known as the Blue Angel program in Germany. This program has been a success since its inception in 1977 and became a world model for eco-labeling programs. Other programs in operation today include the White Swan in the Nordic countries, Environmental Choice in Canada, EcoMark in Japan, and Environmental Labeling in Korea. At least 30 Type I EL programs are operated in the world today; however, there are significant disparities among these programs. Some programs are well recognized in the market, while others are not. For some programs it is difficult to get the certification label, while for others, it is not.

Type I EL programs award their environmental label to products that meet a set of predetermined requirements (e.g. product environmental criteria, product function characteristics, etc.). The label thus identifies products which are determined to have less stress on the environment within a particular product category. The key point here is how the environmental friendliness of a product is determined. The standard on Type I EL states that products should meet an environmental criteria which is based on life cycle considerations (ISO c, 1997). This means that the product must demonstrate environmental superiority over competing products throughout its life cycle.

The life cycle considerations imply that environmental burdens resulting from a product in its life cycle must be identified and quantified. The environmental burdens are the only criteria in judging the environmental friendliness of a product. The program identifies the key environmental criteria which are critical to the protection of the environment within a particular product category. The selection of criteria shall not lead to the transfer of impacts from one stage of the life cycle to another or from one medium to another without a nett gain of environmental benefit (ISO c, 1997).

Selection of environmental criteria for a product category may be explained by citing an example for a refrigerator. Assume that the life cycle assessment of a refrigerator showed that energy consumption in the use phase, chlorofluorocarbon (CFC) use as refrigerant in the manufacturing phase and plastic components recycling in the disposal phase are major sources of environmental burdens. Then the electricity consumption in the use phase, CFC leakage in the manufacturing phase and recyclability or recycling percentage of the plastic components in the disposal phase become the environmental criteria of the product category named refrigerator. Specific values are assigned to each environmental criteria, which are used to determine which products receive the eco-label. The practitioner controls the percentage of products that are awarded the label by controlling the numerical values for each relevant criterion. This results in the selectivity of a label.

The Type I EL program is a pass-fail system; only products meeting the specific values imposed by the Type I criteria can obtain the label. However, due to the selectivity principle, only 20 to 30% of products are awarded the label within a particular product category. Products which cannot obtain the label may have disadvantages in competing against the products which have the label.

An alternative to the Type I program is the Type III environmental declarations program (ISO 14025). The Type III program is based on preset categories of parameters which are determined from Life Cycle Assessment (LCA) results. Environmental burdens and impacts accrued from the life cycle of a product are cataloged according to the preset categories of parameters. This is similar to the concept used in food labels when nutritional information is displayed on the label. The Type III environmental declarations practice, is to display information of a product's environmental burdens which would occur in its life cycle.

The Type III environmental declarations program is not a pass-fail system. In addition, the program is regarded more suitable for the transactions of raw materials, ancillary materials and components among businesses rather than final products for retail consumers. This fact indicates that the Type III environmental declarations program may be a viable tool in the implementation of a green purchasing network (GPN). Thus, the Type III program differs from the Type I EL program.

WORKING GROUP 2 TASKS

The proliferation of environmental claims, particularly those which are non-verifiable, deceptive and inaccurate, is a major threat to the sound use of the environmental claims. Furthermore, most environmental claims did not consider the environmental burdens of a product or service throughout its life cycle. Therefore, there was a need for standards of self-declared environmental claims which require, where appropriate, life cycle considerations be taken into account when such claims are developed.

Self-declared environmental claims (known as Type II EL: ISO 14021) are environmental claims made without independent third-party certification. The claim may be made by manufacturers, importers, distributors, retailers or anyone else likely to benefit from a such claim. Environmental claims are statements, symbols or graphics that indicate the environmental aspects of a product or service. An environmental claim may be made on product or packaging labels, product literature, technical bulletins, advertizing, publicity or similar applications (ISO b, 1997). Terms such as 'recyclable' and 'biodegradable' are examples of statements and the Mobius loop is an example of a symbol. The fundamental difference between self-declared environmental claims and Type I and III programs are that the former is made by the claimant while the latter by the third party.

The benefit for supporting self-declared environmental claims is that they may encourage demand for those products and services that cause less stress on the environment, thereby stimulating the potential for market driven continuous environmental improvement (ISO b, 1997). However, the claims should be accurate, verifiable, and not misleading to ensure fair competition in the market. Many nations have regulations and guides regarding the self-declared environmental claims and impose penalties for those violating the regulations and guides. Since there are many different regulations, the objective of this standard is to provide some consistency in the use of self-declared environmental claims.

There are twelve specific claims that represent terms commonly used in environmental claims that are addressed in this standard. They are: Recycled Content/Recycled Material, Reduced Resource Use, Recovered Energy, Waste Reduction, Reduced Energy Consumption, Reduced Water Consumption, Extended Life Product, Reusable and Refillable, Recyclable, Designed for Disassembly, Compostable, and Degradable. Specifications of these claims and qualifications for their use are provided in the standard.

In addition to the specific claims, the standard provides general requirements for all environmental claims. A total of eighteen specific requirements is delineated. That self-declared environmental claims shall be accurate and not misleading, be substantiated and verifiable, be relevant to that particular product, be specific as to the environmental aspect, be unlikely to result in misinterpretation, etc, are examples of the specific requirements. One of the requirements is that the principles set out in ISO 14020 shall also apply.

Claims that are vague or non-specific or which broadly imply that a product is environmentally beneficial or benign shall not be used (ISO b, 1997). Examples are environmental claims such as 'environmentally safe', 'environmentally friendly', 'earth friendly', 'green', 'nature's friend' and 'ozone friendly'. Claims of sustainability are not permitted.

The specific symbol selected in the standard is the Mobius Loop (Figure 2). It is a graphical symbol in the shape of three chasing arrows forming a triangle. The Mobius loop applies to the product or packaging for claims of recyclable and recycled content (ISO b, 1997).

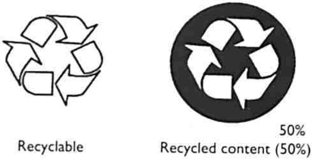

Figure 2 : Examples of the Mobius Loop

WORKING GROUP 3 TASKS

This working group prepared ISO 14020 which deals with the general principles of environmental labels and declarations. These principles shall be applied to the development and use of new environmental labels and declarations. This means that Type I, Type II, Type III EL and any future standards on environmental labels and declarations shall include the principles of this standard.

There are nine general principles. Key fundamental principles are that environmental labels and declarations: (1) shall be accurate, verifiable, relevant, and non-deceptive, (2) shall be based on scientific methodology, (3) shall not inhibit innovation, and (4) should consider the life cycle of the product or service (ISO a, 1997). Other principles are related to information used to develop the environmental claims, the process for developing labels, administrative requirements, and trade issues.

The principle concerning trade (principle 2) is one of the most important principles in this standard. It states that procedures and requirements for environmental labels and declarations shall not be prepared, adopted, or applied with a view to, or with the effect of, creating unnecessary obstacles to international trade. It further notes that the provisions and interpretations of the WTO should be taken into account (ISO a, 1997).

IMPLICATIONS OF ISO 14020 SERIES ON INTERNATIONAL AND DOMESTIC TRADE

The Type III label is similar to the environmental data book in concept. However, there are major differences. The Type III label lists environmental data of a single product quite extensively, while the environmental data book lists a limited number of environmental data of all products belonging to a given product category. The information on the Type III label is based on the critically reviewed LCA study results. The information in the environmental data book, however, is not verified by an independent third party and use of LCA results is not a mandatory requirement. This indicates that the Type III label provides much more credible and transparent environmental information than the environmental data book. For effective implementation of the GPN, therefore, the Type III label would be preferable to the environmental data book.

Self-declared environmental claims have been practised for a long time and are open to everyone. No limitations in product categories nor selectivity principles exist. As long as they comply with the requirements in ISO 14021, producers can use the environmental claims. However, the significance of ISO 14021 to international trade, among others, is the requirement related to the process issue. This requirement says that "A self-declared environmental claim shall be relevant to the geographic area where the corresponding environmental impact occurs (ISO b, 1997)." It is followed by a note stating that "A process-related claim can be made anywhere, so long as the environmental aspects occur in the geographic area where the process is located." This means that environmental claims relevant to the exporting country may be made in the imported country.

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13 DESIGN FOR THE ENVIRONMENT

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Design for the environment (DFE) which includes elements of resource conservation and prevention of pollution is being applied in various product sectors. DFE incorporates approaches which are part of product concept, need and design. DFE consideration involves material selection, material and energy efficiency, reuse, maintainability, and design for disassembly and recyclability. This document contains material from the AFNOR Standard on DFE, 1997.

The processing of a used product must be considered early in the design stage taking into account requirements like demountability, reusability and recoverability as a function of the product's different possible future uses. A similar concept applies to the potential impacts on the environment at each stage of the product's life cycle.

This standard provides some general principles to assist designers in integrating the reduction in the potential impacts on the environment into their practices. It is to be adapted to the technical and methodological context specific to the company involved. Since there are limitations to all methods, it is important to fully understand those specifications and take into account the environmental dimension in the design and development of products. The limits to the design choices are statutory, technical and economic, and they apply to both environmental protection and product safety.

For all the stages of the product's life cycle and also end of life, the designer shall comply with the environmental regulations in force. He shall also take into account voluntary commitment, such as good code of practice which agrees on returning of packaging material.

SCOPE

The standard provides guidelines, some general principles and information for the application of DFE and is intended to enable designers to take into consideration the environmental aspects as early as preliminary marketing and functional analyses phases up to the technical choice and redefinition phases.

The standard is applicable to all the sectors who wish to adopt, develop and adapt the principles in the design and development of products. It does not provide the detailed techniques to be implemented, but it encourages the configuration and adaptation of the appropriate tools for each product.

The standard also considers environmental factors when assessing the potential impacts associated with the inputs and outputs, and designing and the developing of products irrespective of the scale of modifications or innovations involved.

GENERAL PRINCIPLES

The need to reduce all of the potential environmental impacts of a product over all stages of the life cycle is well acknowledged and understood. To achieve this reduction progressively and efficiently, it is crucial to

1. introduce the environmental dimension into the design methods that deal with other dimensions of the design project: quality, cost, production time, and

2. take into account the global environmental dimensions to prevent designers from making unfavorable decisions which would result in increases in environmental impacts.

Principle 1: Global Integration of the Environment

The integration of the environmental dimension into design considers the diverse categories of potential impacts of a product assessed at each stage of its life cycle. This can result in the use of known environmental assessment tools.

Multicriteria Approach

As much as possible the designer shall take into consideration the potential impacts including samplings and discharges to air, land and water, and other criteria like odors, disfigurement, land use, noise and hazards. This multicriteria approach ensures that the reduction of potential impacts in one stage will not cause an increase in other stages (transfer of nuisance). Any exclusion of an environmental criterion shall be justified.

Life Cycle Approach

The life cycle approach considers all stages of the life of a product in order to assess the consequences the product has on the environment. The principal stages of a product's life cycle are extraction of the raw materials, production, distribution, use and processing of the used product.

One initial approach is to define the relative importance of the different life cycle stages and to avoid focusing on the analysis of a single stage. For example, for products having a short life time (packaging), consideration should be given to reduction at source or end-of-life elimination method. Conversely, for products having a long life time, consideration should be on the use phase.

Principle 2: Integration of the Environment into the Design Methods

The efficient integration of the environment into the design should be made at the upstream phase and should integrate additional methods within the product design methods. As this integration can only be carried out progressively, it must be based on the continuous improvement concept.

Integration of the Environment at Each Design Stage

The product design method comprises several stages: preliminary study, functional definition of the product, preliminary design and detailed design. At each stage, choices in terms of technical principles, geometric definition, materials, production method and assembly method are made by taking into account certain economic, statutory and technical limits.

Because these choices depend on the nature and intensity of the inputs and outputs of each life cycle phase, it is important to introduce additional procedures to the product design method to integrate the environmental dimension at each design stage.

Intervention as far Upstream as Possible in Design

During the design, the closer to the production phase, the more the possibilities for the reduction of the environmental impacts of a product diminishes. Furthermore, the later the environment is integrated, the more expensive the modifications will be. Therefore, the environmental dimension should be introduced into the design as far upstream as possible.

In the case of value analysis, one of the first steps is to conduct functional analysis which consists of organizing, characterizing and ordering into a hierarchy the functions of the product. It is at this early stage that the notions of environmental protection shall be introduced (energy consumption, demountability, recoverability, contaminating emissions).

Continuous Improvement

The integration of the environmental dimension into design should be a continuous improvement process resulting in the introduction of additional methods. Thus, it is possible to take into account technical or market developments, both upstream (development of new materials) and downstream (drawing up of new recovery process) of the product's life cycle.

It is also recommended that the feedback of the different experiences gained during the different design process phases be organized to enrich knowledge base. For example, all information required for conducting an environmental assessment or set of design rules should be shared with others involved in design.

Principle 3: Use of Evaluation Methods and Tools

To assist the designer in obtaining a product which presents reduced environmental impacts, additional methods shall include at least environmental analysis tools and a series of impact reduction strategies.

Environmental analysis tools allow the designer to make the best choices each time several alternatives are offered within the product design process. These tools may be a set of indicators specific to the company's physical parameters (mass, volume) or technical parameters (percentage of recycled material, dismantling time), supplemented by known environmental assessment tools (LCA, energy content).

The impact reduction strategies discussed earlier shall assist the designer to improve the product at each stage of the product design process.

Principle 4: Combination of Strategies for the Reduction of Potential Impacts

To reduce potential impacts for the same service rendered, the designer is advised to combine the impact reduction strategies covering at least three strategies: optimization of the service rendered by the product related to the same functional unit; preservation of resources; and prevention of pollution, waste and nuisances.

These strategies will enable the designer to investigate different paths which must be considered. Their validity for a specific design project and for a given industrial sector shall be verified. (Refer to Annex B of the Standard).

Strategy for Optimization of the Service Rendered by the Product

This third strategy is based on the notions of durability and dematerialization and comprises improving the function, performance and use duration of a product without increasing the potential impacts of the product over its life cycle. Dematerialization, in this context, refers to trimming down, replacement of the sale of a product by a service or circulation of information rather than of materials.

Strategy for Preservation of Resources

This strategy is aimed at reducing as much as possible the quantity of resources required for a product without detriment to its functions, life time and performance. Furthermore, the reduction at the source of the quantity of resources required for a product can lead to reduction in pollution and nuisances. For example, less energy consumed means less emission into the atmosphere, less raw materials and energy to be extracted and less associated transportation.

This strategy gives good results in the context of a given technological solution, but it is more difficult to apply when there are technological advances. For example, the replacement of an electromagnetic circuit with an equivalent electronic circuit results in an environmental gain in weight and energy, and possible accumulation of other impacts on the environment (toxicity).

Strategy for Prevention of Pollution, Waste and Nuisances

To reduce pollution and nuisances generated by a product over its life cycle, curative processing methods are used including sewage treatment plants, smoke filters and waste incinerators. However, this processing does not completely eliminate pollution, waste and nuisances. Instead it gives rise to depollution residue, such as sewage treatment plant sludge, ashes and slag. Therefore, preferable measures would be to handle the problem of pollution, waste and nuisances at source in order to minimize the environmental impacts.

Principle 5: Dialogue and Partnership

Actors

To design products which are environmentally friendly involves a more collective approach. A minimum of three partners participate in the design of the product: the designer, the supplier and the customer. The designer shall consider the players of the end-of-life processes: the recycler and the dismantlor.

The choices cannot be made separately and they shall thus rely on a set of data which meets an expressed and realistic need. The partnership contributes some advantages because it leads to more effective solutions and facilitates the integration of experience feedback.

Dialogue

The dialogue and partnership sought are for both the product design choices, and communication and subsequent collaboration. This involves transparency which can only be limited by commercial secrecy constraints.

Information and Cooperation

Professional player information - The designer should regroup, match and validate the information concerning the environmental aspects of the product. This information concerns the use-related precautions, maintenance or the end-of-life operations. The designer should make provision for procedures for transmission of this information to the professional players who intervene in the product design at different stages of its life cycle and should ensure the cooperation between the two parties.

Consumer information - Making provision for information adapted for the consumer can form part of the product development data. This is likely to reduce the potential impacts on the environment, in particular in the use phase, the maintenance operations and the end of life.

For example, the instruction manual for a refrigerator can provide information on the selection of the optimum temperature, thus avoiding the premature deterioration of foodstuff, and excess energy consumption.

IMPLEMENTATION OF PRINCIPLES

The application of the five principles discussed above is incorporated into the traditional stages of product design and development.

Context

There are constraints in determining the product design choices. These constraints are the market, usability, safety and economy, and impacts on the environment. These elements determine the technical choices made at the design stage and are likely to have an environmental impact.

The designer's ultimate objective will be to balance the advantages and disadvantages over a large number of alternatives. Therefore, it is recommended that the designer proceed in the following stages:

1. Identification of the impacts on the environment
2. Hierarchical organization of these impacts
3. Consideration of the significant impacts in the selection criteria (final optimization)

Functional Analysis

A need analysis of the functions leads to the drawing up of the functional performance specification which constitutes the designer's reference document. At this stage, possible solutions will be explored during the course of the development to comply with the functional performance specification, without favoring any of the solutions.

The functional unit should be precisely defined at this stage. The question of the use unit which characterizes the expected result is linked to the functions being studied. The rationale is to permit comparison between the different solutions; therefore the use unit will subsequently serve as a comparison standard between the different solutions at environmental level.

Quest for Technical Solutions

To satisfy the functions expected of the product and those listed in the functional performance specification, the designer relies on the research department to identify and work out the different solutions and technical orientations. In general, it is a question of combinations of interdependent solutions.

The different solutions identified make it possible to draw up an initial list of the available information. This information could include the materials implemented or energy consumed, and could lead to the subsequent assessment of the environmental quality of the product being developed.

Choice of a Technical Solution

As described earlier in this section, the designer shall try to optimize all the criteria concerning the market, usability, safety, economy and impacts on the environment. All of the technical data relative to the design of the product within the framework of the solution is compiled in the product specification.

Diverse Studies

Continuation of the product development materializes when a plan is drawn up which leads to the manufacture of prototypes in accordance with the specifications.

Validation of the Chosen Solution

Tests and modeling of reduced-scale products are conducted on the basis of the prototype or experimental models. The data obtained from the tests are compared with the reference data relative to the existing product.

Testing the solutions found based on the weak points detected throughout the life cycle and ensuring that the scale factor does not result in any additional nuisances are advisable.

Industrialized Product

Once the product is industrialized, one can proceed with the actual size. The information gathered can be useful during the industrialization phase for the final development of the product, for improving its maintenance, for reducing the impact factors linked to the production stages, for improving the specifications and for other relevant actions.

Product Use, Maintenance Phase and Experience Feedback

In the use, maintenance and end-of-life phase of the product, true data can be acquired in view of new developments. The development cycle makes it possible to complete the study and to draw conclusions for future products.

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Annex A (informative)

Strategy for optimization of the service rendered by the product, preservation of resources and reduction in pollution, waste and nuisances: examples of paths to be examined

It is recommended to the designer to examine the following paths, to identify those which are pertinent within the industrial sector concerned and for the product concerned:

- recovery of the expended but unused energies
- use of energies of which the sources are renewable
- possibility of reducing the transport distances
- water savings
- space optimization
- weight and volume of the product and of its packaging
- possibility of using low energy consumption products
- possibility of promoting the circulation of information rather than that of the material
- possibility of using renewable materials
- recovery of the used products and of the production waste (recycling, energy recovery, etc.)
- possibility of taking back used products
- making of materials
- possibility of reuse of the product's components
- use of recyclable materials
- use of energetically recovered materials
- possibility of using biodergradable materials
- demountability of products
- optimisation of the product's life time
- product's repairability
- possibility of adding functions to the product
- possibility of reducing product's non-utilization time
- possibility of streamlining the product
- possibility of replacing the product by the sale of a service based on the corresponding product
- hazards related to the use of substances classified as dangerous by the regulations
- noise reduction
- etc.

This list is not exhaustive, it is up to the designer to carry out creative research work in order to supplement it and adapt it to the product and industrial sector concerned.

In addition, it is advisable to determine, on a case-by-case basis, as to whether the technical options corresponding to these paths increase or decrease the impacts related to the functional unit.

14 ENVIRONMENTAL ASPECTS IN PRODUCT STANDARDS

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The development of ISO 14000 Series of Standards on environmental management systems in 1993 has lead to the publication of six standards in 1997. The standards published were:

ISO 14001	Specification with Guidance for Use
ISO 14004	General Guidelines on Principles, Systems and Supporting Techniques
ISO 14010	General Principles of Environmental Auditing
ISO 14011	Procedures for Auditing of EMS
ISO 14012	Qualification Criteria for Environmental Auditors
ISO Guide 64	Guide for the Inclusion of Environmental Aspects in Product Standards

Although these standards are still new to industry, many companies have already decided to adopt them due to increasing pressure from customers, local governments, various other interested parties and the general public. ISO 14001 is the most popular standard because by meeting its requirements, companies gain certification from an accredited certification body. ISO 14004 provides guidelines for companies to implement environmental management systems to meet the ISO 14001 requirements.

ISO 14010, 14011 and 14012 are guidelines for environmental auditing. These three documents provide guidelines for companies on environmental auditing principles and procedures, and on qualification of environmental auditors.

The ISO Guide 64 is the guide for the inclusion of environmental aspects in product standards. This set of standards is intended for standard writers to consider environmental impact in developing product standards. This article will further discuss these standards and the inclusion of environmental aspects in product standards.

SCOPE

The ISO Guide 64 has been developed in order to ensure that environmental impact is taken into consideration in developing any product standards and is intended for standard writers (any person taking part in the preparation of standards) with the following objectives:

1. To raise awareness that provisions in product standards can have both negative and positive environmental impact
2. To establish the relationship between product standards and the environment
3. To avoid provisions in product standards that may lead to adverse environmental impacts
4. To emphasize that addressing environmental aspects during the development of product standards is a complex process and requires balancing competing priorities
3. To recommend the use of life-cycle thinking and recognized scientific techniques when addressing environmental aspects of a product being standardized

To achieve the above objectives, the ISO Guide 64 provides the following guidelines:

1. General considerations that should be taken into account when developing product standards that result in proper balance between product function and environmental impacts
2. Ways in which provisions in product standards may affect the environment during the different stages of a product's life cycle
3. Techniques for identifying and assessing the environmental impacts of provisions in product standards
4. Ways to reduce adverse environmental impacts resulting from provisions in product standards

GENERAL CONSIDERATIONS

Every product has an impact on the environment at some stage in the product's life cycle. The impact can be local, regional or global, or a combination of all three. Identifying a product's environmental impacts is complex and this may have consequences at any or all stages of a product's life cycle. Agreement on environmental cause-and-effect relationships is also lacking.

Despite the difficulties involved, consideration should be given to a product's environmental impact when product standards are developed on methods (prevention of pollution, resource conservation, etc.) to reduce adverse environmental impacts and on the intended use and possible misuse of a product.

A product's environmental impacts should be balanced against other factors, such as product function, performance, safety and health, cost, marketability and quality, legal and regulatory requirements. Review of product standards should be considered whenever adverse environmental impacts might be significantly reduced by the application of new knowledge. Those provisions in product standards which are too restrictive may have the unintended effect of stifling innovation, and these must also be taken into consideration.

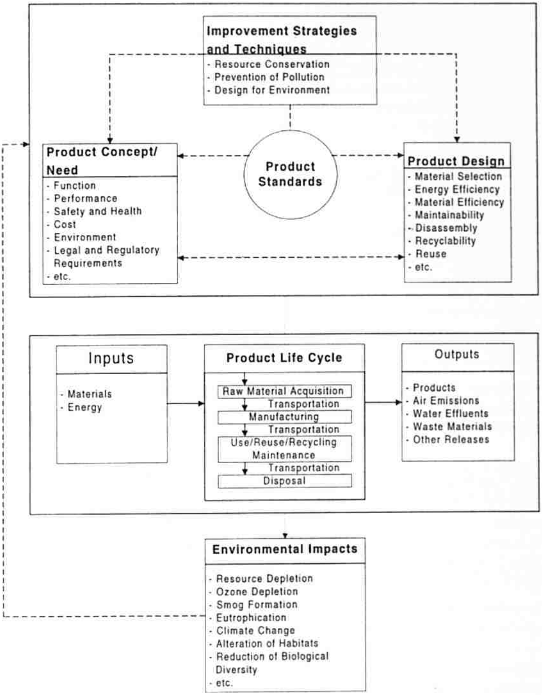

Figure 1 : Relationship Among Inputs and Outputs and Environmental Impacts Generated during a Product's Life Cycle. (Source : ISO Guide 64, 1997)

INFLUENCE OF PROVISIONS IN PRODUCT STANDARDS ON THE ENVIRONMENT

In developing product standards, it is important to recognize how products can affect the environment at different stages of their life cycle. The specific provisions of the product standard will, to some extent, determine the relevant environmental aspects peculiar to the product covered by the standard. To avoid excessive or inefficient material or energy use, provisions should not be too stringent to achieve the product's purpose throughout its expected life. Conversely, provisions that are unduly lax may force the product to be frequently replaced.

When specifying either descriptive or performance requirements, provisions in product standards affect the choices made during the design and production of a new or improved product. During all stages of the product's life cycle these choices can influence the following factors:

1. The inputs and outputs associated with production processes
2. The inputs and outputs associated with packaging, transportation, distribution and use
3. The options for reuse and recovery, including recycling or energy recovery from the product, its ease of disassembly, repair and restoration
4. The option for disposal of the product and associated waste

The impacts these choices have on the environment will vary from product to product. Not all products will affect environmental quality at all stages of their life cycle.

Due to the interrelation of a product's environmental impacts, emphasis on a single environmental impact may change environmental impacts at other stages of the product's life cycle or in other aspects of the local, regional or global environment.

INPUTS AND OUTPUTS TO BE CONSIDERED IN THE DEVELOPMENT OF PRODUCT STANDARDS

A product's environmental impacts are largely determined by the inputs that are used and the outputs that are generated at all stages of the product's life cycle. Changing any input, either to alter the materials and energy used or to influence a single output may affect other inputs and outputs. (Refer to Figure 1 of ISO Guide 64).

Inputs fall into two broad categories: materials and energy. Material inputs to the raw material acquisition, product development, manufacturing, transportation (including packaging and storage), use/maintenance, reuse/recycling, and disposal of products can produce a variety of environmental impacts. These impacts include depletion of renewable and non-renewable resources, detrimental land use, and environmental or human exposure to hazardous materials. Material inputs also contribute to the generation of waste, emissions to air and water, and other releases to the environment.

In addition to material inputs, energy inputs are also required at most stages of a product's life cycle. Energy sources include fossil fuels, nuclear energy, recovered waste, hydroelectric, geothermal, solar and wind energy, and other sources. Each energy source has its own environmental impacts.

The outputs generated during a product's life cycle, comprise the product itself, intermediates and by-products, air emissions, water effluents, waste materials and other releases to the environment. Air emissions comprise releases of gases, vapors or particulate matter to the air. Releases of toxic, corrosive, flammable, explosive, acidic or odorous substances may adversely affect flora, fauna, human beings and/or contribute to other environmental impacts including depletion of stratospheric ozone or formation of smog. Air emissions include releases from point or diffuse sources, normal operations, and accidental, treated and untreated releases to the environment.

Another form of outputs are water effluents which comprise the discharge of substances to a watercourse, either surface or ground water. The discharge of nutrients or toxic, corrosive, radioactive, persistent, accumulating or oxygen-depleting substances may give rise to adverse environmental impacts including various pollution effects on aquatic ecosystems and undesirable eutrophication of natural waters. Water effluents include discharges from point, diffuse sources, normal operation, and treated, untreated and accidental discharges.

Waste materials comprise solid or liquid materials or products which are disposed of. They may be produced any stage of a product's life cycle. They are subject to recycling, treatment, recovery or disposal techniques associated with inputs and outputs, which may contribute to adverse environmental impacts. Other releases to the environment may encompass emissions to soil, noise and vibration, radiation and waste heat.

TECHNIQUES FOR IDENTIFYING AND ASSESSING ENVIRONMENTAL IMPACTS

Accurate identification and assessment of how provisions in product standards influence the product's environmental impacts is complex, and needs careful consideration by and consultation with experts. Certain techniques are evolving to guide the identification and assessment of a product's environmental impacts. Although a complete understanding of these techniques and their limitations requires extensive experience and study of the environmental sciences, awareness of these techniques offers some general understanding of how provisions in product standards may influence a product's environmental impacts.

One example of such techniques is Life Cycle Assessment (LCA). LCA is a technique for assessing the environmental aspects and potential impacts associated with a product by

1. compiling inventory of relevant inputs and outputs of a system,
2. evaluating the potential environmental impacts associated with those inputs and outputs, and
3. interpreting the results of the inventory and impact phases in relation to the objectives of the study.

LCA studies the environmental aspects and potential impacts throughout a product's life (cradle-to-grave) from raw material acquisition through production, use and disposal. The general categories of environmental impacts that need consideration include resource use, human health and ecological consequences.

LCA can assist in

1. identifying opportunities to improve the environmental aspects of products at various points in their life cycle,
2. making decisions in industry, governmental or non-governmental organizations (strategic planning, priority setting, product or process design, redesign),
3. selecting relevant indicators of environmental performance, including measurement techniques, and
4. marketing of products through environmental claims, eco-labeling schemes or environmental product declarations.

LCA is still in the early stages of its development. Considerable work needs to be done and practical experience must be gained to further develop the level of LCA practice. Therefore, it is important that the results of LCA be interpreted and applied appropriately.

Another example of a technique for identifying and assessing environmental impacts is the Environmental Impact Assessment (EIA) which is described in IEC Guide 109:1995, Annex B 'Guidance on Environmental Impact Assessment (IEA) : Principles for the Electrotechnical Industry'.

EIA can be used in studying environmental issues in product standards. It can assist in meeting the requirements for an environmentally desirable product, including environmentally compatible use, reuse and disposal of such a product. Materials and substances that go into a product are particularly critical at the end of life. This consideration leads to issues of the product's recyclability and proper disposal.

The relevance and value of the technique used to identify and assess a product's environmental impacts vary depending upon the product and the product sector involved. Improper application of the technique may result in an incomplete or distorted picture of the environmental impacts and the trade-offs associated with a product.

RELATIONSHIP OF PRODUCT STANDARDS TO STRATEGIES AND TECHNIQUES FOR ENVIRONMENTAL IMPROVEMENT

General Considerations

Provisions in product standards may both facilitate and hamper environmental improvement. Unless necessary for important reasons (health, safety or performance of the product), any standards set should avoid specifying materials to be used in the products. Specifying materials may preclude innovation and the development of new ways of reducing adverse environmental impacts through the use of alternative materials. For instance, provisions in product standards should not preclude the appropriate use of secondary or recycled materials. If materials are to be specified, consideration should be given to how the use of a specified material will affect the environment at all stages of the product's life cycle.

In writing the product standards, strategies and techniques for environmental improvement may be represented by resource conservation, prevention of pollution and design for the environment.

Resource Conservation

In addition to environmental impacts associated with resource acquisition and use, resource depletion is of great interest environmentally. Resource depletion refers to the process of diminishing stocks of natural resources.

Renewable resources can be replenished at significant rates. This includes most biological populations, such as timber resources. However, human activity can affect the rate of replenishment of biological populations and lead to serious declines.

Non-renewable resources are those which cannot be replenished in the period of a human lifespan. Mineral deposits, fossil fuels and biologically diverse species are non-renewable resources.

Other than resource conservation, conservation of energy is also an environmental concern. Different sources of energy, conversion efficiency of selected sources and efficient use of energy are areas that can result in environmental impacts. Substantial environmental trade-offs may exist among energy sources.

Prevention of Pollution

Human and industrial activities result in releases to air, land and water. There are several means of reducing these releases, including source reduction, material substitution, in-process recycling, reuse, recycling and treatment to reduce hazards or volume.

There are also various types of releases which may lead to environmental impacts including climate change, ozone depletion, habitat alteration, impacts on biological diversity and other long-term impacts. When addressing these issues, standard writers should consider sector-specific expertise and precautionary approaches.

Design for the Environment

Design for the environment (DFE) which includes elements of resource conservation and prevention of pollution is being applied in various product sectors. When developing product standards, standard writers should be aware of these techniques. For example, DFE incorporates approaches which are part of product concept, need and design. Considerations involve material selection, material and energy efficiency, reuse, maintainability, and design for disassembly and recyclability.

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15 STRATEGIES TO OVERCOME BARRIERS TO ISO 14001 EMS DEVELOPMENT AND IMPLEMENTATION FOR SMIs IN MALAYSIA

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A sound Environmental Management System (EMS) must be developed before an ISO 14001 certification can be achieved and audited. Small and medium industries (SMIs), in both developed and developing countries, tend to face greater difficulties in developing an EMS especially in terms of cost (UNCTAD, 1997). A good strategy with adequate efforts will ensure the development of a sound EMS (Chong, 1998). The preparatory work involved in the development of an EMS is quite immense and depends on the current state of the organization in terms of its environmental management (Block, 1997). While ISO 14001 EMS promises to stimulate internal improvements and result ultimately in increased market shares, the barriers that exist during the preparatory stages must be overcome. Development of an EMS from the ISO 14001 standard is not automatic. ISO 14001 EMS standard provides only skeletal guidance, specifying that a company must undertake the following:

1. Create an environmental policy
2. Set environmental objectives and targets
3. Implement a program to achieve those objectives
4. Monitor and measure the system's effectiveness
5. Correct problems
6. Continuously review the system and improve overall environmental performance

It is important to understand that conformance to ISO 14001 does not guarantee better environmental performance. The standard is generic and only provides the framework within which organizations will establish, achieve, and control whatever level of environmental performance set by the organizations themselves. The standard is designed in a manner such that it is at the discretion of the organization to 'put the flesh on the bones' to realize actual benefits. In the course of an SMI's effort to create and develop its own EMS, many potential barriers exist. Failure to recognize and overcome these problems can lead to major difficulties in the setting up of the system.

This chapter presents an overview of the barriers to ISO 14001 EMS implementation and its impacts on developing countries. From the experiences of other organizations worldwide, strategies are recommended for methods to remove obstacles that hinder organizations, the SMIs in particular, in their efforts to develop and implement EMSs.

BARRIERS TO IMPLEMENTATION OF ISO 14001 AND THEIR IMPACT ON TRADE OF DEVELOPING COUNTRIES

Lack of Top Management Commitment

Lack of government incentives, insufficient information, and lack of awareness are some of the possible reasons for insufficient commitment by the management of firms in developing countries to implement an EMS. Lack of management commitment might also be due to the perceived intricacy of the ISO 14001 standard, confusion about the compatibility of ISO 9000 and ISO 14001, and the impression that implementation of the standard is associated with too much paper work.

In Mexico, experience with ISO 9000 has shown that the limited attention traditionally devoted to procedures, documentation and records presents an obstacle for ISO 9000 implementation. In Nigerian organizations, a preference for individual decision making is often combined with a lack of clearly defined organizational structures and lack of employee training. Many managers are not committed to implement any management system because systematic measures might interfere with individual decision making. The required documentation of processes and procedures, for example, could reveal malpractice, corruption, or decision making following priorities such as personal requests from superiors, religious requirements, or tribal loyalties.

Lack of Resources and Infrastructure

A lack of resources, such as information, capital, technology, training facilities, and qualified consultants and auditors in many developing countries might be a barrier to implementation of ISO 14001. Alterations in the structure and operations of an organization required by the standard involve experience and expertise that might not exist in developing countries.

Small organizations in particular may find the high costs involved in complying with ISO 14001 prohibitive. A lack of clean technologies is a potential obstacle for developing country producers in complying with environmental legislation and achieving conformity with ISO 14001.

Developing countries describe the access to information on the proposed standards as insufficient. Most developing countries do not have sufficient financial resources to attend TC 207 meetings. Hence, it is more difficult for them to bring to the attention of policy makers in their respective countries and thus to influence the standard-setting process. This fact might also create the idea that the standards are largely a developed country issue and may provide a guise for new types of conditionality.

ISO 14001 as a voluntary scheme is based on the existence of national environmental legislation, which an organization can use as a basis to formulate its environmental policy and objectives. This legislation is often lacking, under development, or is badly implemented and enforced in most developing countries. Another difficulty might be that some regulatory bodies do not recognize EMS because of different priorities within the existing legal system. For example, in India, a command and control regulatory framework is encouraging end-of-pipe pollution control, while EMS focuses on preventive strategies.

Experience with ISO 9000 has shown that many developing countries do not have national certification bodies to assess conformity with the specifications of the standards. Absence of local conformity assessment infrastructure increases the costs of compliance for exporters in developing countries. Hence, they are forced to seek registration by overseas certifiers or international bodies. As with ISO 9000, even if certification infrastructures exist in developing countries, certificates issued by a local body might not be accredited by organizations or governments in the target markets because of a lack of confidence and credibility. Experience with ISO 9000 showed that importers in industrialized countries often requested certificates from reputable foreign or international bodies. The credibility of a certification system depends largely on the competence of the auditors who carry out the assessments. In the absence of an international system for qualifying auditors, personnel from developing countries must obtain this expertise by enrolling in training courses from organizations abroad. The problem with gaining credibility is that there is a strong reputation effect involved. The credibility of a certification body might be considered differently by various trading partners and is to some extent subjective.

Lack of Uniformity in Conformity Assessment

The generic nature of ISO 14001 leaves a lot of room for interpretation by users of the standard. Terms such as 'relevant', 'significant', or, the requirement of 'continual improvement' might be difficult to assess and are interpreted differently by users (such as consultants and certifiers) in different countries. As such, the influence of standard users on international trade becomes very great. ISO 9000 has already been criticized for being too commercial and thus open to misuse by consultants. There are different models of national conformity assessment systems among developed countries. The criteria for certifiers to certify organizations are not internationally harmonized. Auditors are not internationally recognized, and auditor training can vary from country to country. ISO develops international standards, but it does not create an international framework for assessing conformity to the standards. Stakeholders worldwide are understandably concerned that the ISO 14001 specification standard be interpreted consistently, that the certifiers are evaluated according to rigorous criteria, that auditors are competent to conduct third-party audits, and that ISO 14001 certificates, once issued, are recognized worldwide.

Nature of SMIs and Implementation Issues

SMIs have been variously described as: (1) willful environmental offenders that are unsophisticated and ignorant with respect to environmental practices, (2) conscientious citizens doing their small part to help, and (3) entrepreneurial innovators at the forefront of green technologies and processes (Johannsen, 1996). It was suggested that the variant nature of SMIs is the basis of reason why it is difficult for SMIs to implement EMS concepts; hence other guidance standards for SMIs' use should be created. It was also suggested that awareness, attitudes, and behavior of SMIs with respect to environmental practices are the same as those of the general public. SMIs also lack structural rigidities and often do not have an environmental committee or ISO 14000 committee. They also do not have detailed work plans (Johannsen, 1996; Stapleton et al., 1996).

Implementation of an EMS is suggested to be similar whether it is in an SMI or a large company. Many opinions have pointed that the "Deming" concept of plan, do, check and act and the principles embodied in the ISO 14001 EMS are conservative in any setting and in fact is said to be more effective compared to that of a larger company (Johannsen, 1997). In smaller organizations, lines of communication are generally less complex, people perform multiple functions, and access to management is easier (Stapleton et al., 1996; Cascio et al. 1996). In addition, the lack of structural rigidities, such as those in SMIs, may allow for easy changes to be made in the manner the organization operates (Block, 1997). However, due to the nature of SMIs, which often lack financial resources, technical expertise, time and human resources, the problems arising during the developmental stages of an EMS might become the major factor that prohibits an SMI from implementing an EMS. SMIs, in both developed and developing countries tend to face greater difficulties in developing EMS (UNCTAD, 1997). In addition, development of an environmental management system in developing countries is more costly.

SMALL AND MEDIUM SIZED INDUSTRIES AND INDUSTRIAL POLLUTION IN MALAYSIA

Small and medium industries (SMIs) are defined as manufacturing industries with a paid-up capital or shareholder's fund of less than RM2.5 million and employing fewer than 75 full time workers (FMM, 1997). SMIs form the main manufacturers in the automotive, electrical and electronics, machinery and engineering, plastics, textiles, rubber, wood and food industries. The important role of SMIs in Malaysia's industrialization process has been clearly stated in the Second Outline Perspective Plan (OPP2) (1991-2000) and Sixth Malaysia Plan (6MP) (1990-1995). SMIs have been characterized as playing a vital role in the overall national economic development as they contribute significantly in terms of income distribution, employment generation, and as the necessary supporting industries in providing parts, components and services to heavy industries and other businesses. The national industrial policy aims to promote and upgrade inter- and intra-industry linkages among SMIs in order to ensure the success of larger industries.

SMIs are crucial in ensuring the success of larger industries and hence, indirectly enhance the production capacity of Malaysia as an industrialising nation. However, many developing countries have underscored the contributions of SMI process and production methods to overall pollution of the environment. One of the major obstacles faced by Malaysia's effort to protect and prevent further environmental degradation is the inability of SMIs to achieve and demonstrate conformance and satisfactory performance in their environmental management. Non-conformances to environmental regulations and other legal requirements were attributed mainly to the lack of financial resources to alter production processes and the management incapacity to deal with its significant environmental aspects (DOE, 1995). However, no objective and documented evidence (pollution control costs, management problems, production alteration costs, etc.) was ever brought to the forefront to verify the SMIs' claims. As such, no effective and problem-oriented corrective actions can be undertaken to assist SMIs manage their problem and as an unfortunate consequence, the environmental degradation by polluting industries persists. There are regulations in place to control SMI industrial pollution in the Environmental Quality Act 1974 and it has specified regulatory compliance standards regarding sewage and industrial effluents, clean air and scheduled wastes for both prescribed and non-prescribed premises. It was suggested that the regulations stated in the EQA 1974 are adequate but are, however, ineffective in controlling industrial pollution. The reason behind the ineffectiveness lies mainly in the shortage of manpower to carry out enforcement compared to the number of SMIs to be regulated. In 1995 alone, SMIs including food and beverage, paper, textile and rubber based as well as electroplating industries had less than 75 percent compliance rate with requirements of the Environmental Quality (Sewage and Industrial Effluents) Regulations 1979. Similarly, metal finishing and electroplating, cement and wood industries were identified as those with compliance problems (compliance rate less than 75 percent) with the Environmental Quality (Clean Air) Regulations 1978 (DOE, 1995).

The developments in the international arena regarding the ISO 14000 standards has various implications on the SMIs in Malaysia especially those SMIs that are export oriented or those attached to multinational organizations which are most definitively conforming to the standard in order to maintain international market competitiveness. Penetration into the global marketplace now not only demands improvements in product quality, production capacity, pricing and marketing strategies (FMM, 1997), but also demands sustainability in industrial practices and environmentally safe products (Johannsen, 1997). It was suggested that the impact of ISO 14000 will be significant for businesses exporting to global markets and their suppliers. Preparing for ISO 14000 today is no longer an option, but a matter of survival in the market.

MALAYSIA AND ISO 14001

In light of the recent developments concerning the ISO 14000 standards, the Malaysian government has expressed a keen interest in encouraging industries to adopt a systems approach towards environmental pollution control and management by incorporating provisions for auditing of environmental management systems in the 1996 Environmental Quality Act Amendment (Looi, 1997). Malaysia had also, through the Standards and Industrial Research Institute of Malaysia Berhad (SIRIM), adopted in December of 1995 the ISO 14000 series[1] as the provisional (P) Malaysian Standards (MS). The decision by the Malaysian government to include legislative provisions for environmental management systems that are verifiable by auditing procedures demonstrates its serious interest in adopting the ISO 14000 standard in regulatory reform initiatives. The choice made by the regulatory body is clear; ISO 14000 is stated to be consistent with the concept of sustainable development and is compatible with various cultural, social and organizational frameworks. The embodiment of the concept of sustainable development of the standard is important, as it has been the basis of environmental policy making in Malaysia (Sani, 1997). These environmental policy directives were reinforced in the Malaysian Government's Second

[1] ISO 14001 and ISO 14004 for EMS, and ISO 14010, ISO 14011 and ISO 14012 for Auditing

Outline Prospective Plan (OPP2) (1991-2000). The OPP2 is in accord with the goal of the Seventh Malaysian Plan to continue the program on greater environmental awareness in both government and private sectors and to prioritize responsible, sustainable and well balanced use of natural resources to protect the requirements of future generations.

There is little experience in implementing the ISO 14001 EMS standard in Malaysia. As of January 1998, 34 companies have been certified. An analysis of its implications for organizations and trade of Malaysia as a developing country can only be based on expectations and experience with similar existing standards, for example, the ISO 9000 series. In the following sections the ISO 14000 standards and the standard's impact on developing country trade with specific reference to ISO 14001 are discussed.

STRATEGIES TO OVERCOME TRADE BARRIERS AND DIFFICULTIES ARISING FROM ISO 14001 IMPLEMENTATION IN MALAYSIA

The barriers to ISO 14001 development and implementation discussed above are most likely applicable to the condition in Malaysia and are heightened in the SMIs. The following paragraphs suggest mechanisms to support SMIs in Malaysia in their effort to integrate environmental management into their export oriented development strategies so as to enhance long-term competitiveness.

The ISO 14000 standards have the potential to ensure some of the negative impacts on developing country trade associated with unilateral EMS standards are avoided. However, whether ISO will achieve its goal of abolishing barriers to trade or even create new goals will depend on many other factors that go beyond the standards setting-process. First, it will be necessary that the ISO 14000 international standards be used as a basis for the design of different national standards on environmental management in order to achieve the intended harmonization. Second, the interpretation and application of the standards must be non-discriminatory. Third, there is a need for technical and financial assistance to support developing countries in taking advantage of trading opportunities that can arise from the ISO 14000 standards. Furthermore, ISO should allow non-member countries access to draft standards in order to minimize possible negative trade impacts arising from a time lag in adjusting to standards' requirements.

Acceptance of the Standard by Government and Industries

The objective of the standard setting to harmonize the conflicting requirements in international trade rests on the assumption that the ISO standard will be used as a basis for the development of different national standards on environmental management. In its Technical Barriers to Trade Agreement (TBT), the World Trade Organization (WTO) encourages its member countries to use relevant international standards as a basis for their national standards (Pfliegner, 1998). As a member of the WTO, Malaysia must carefully control its activities on standards setting and conformity assessment with respect to the TBT agreement which foresees practices for the preparation, adoption and application of standards that prevent them from creating barriers to international trade.

The Malaysian government has taken a significant step in its acceptance of the ISO standard by adopting the standard as a Malaysian Standard in 1995. The government has also made legal provisions for environmental management system auditing in the EQA 1974. The actions of the government might be due to the recognition of the potential impact that the international standard will have on the nation's export oriented businesses with the anticipation of the trade liberalization phenomenon soon to occur in Malaysia. Nevertheless, more can be done by the government to facilitate the acceptance of the standard on environmental management by industry as elaborated in the next section.

Industries in Malaysia must also accept the standard in order to avoid any trade implications on their exports. In particular, the SMIs must be encouraged to accept and implement the standard in order for them not to be excluded from the local and international marketplace. As experienced by other countries, non-compliance to the standard can become a local barrier to trade. Multinationals in Malaysia, who are most likely seeking certification to the standard might impose a certification requirement upon its vendors - mainly composed of SMIs as well.

Technical and Financial Assistance

Acceptance of the standard by industry necessitates overcoming the various implementation barriers as described earlier. These barriers include, among others - lack of top management commitment, lack of resources and infrastructure, and high development and implementation costs. Government and industry have to work together to create a favorable atmosphere for acceptance of the standard in Malaysia.

Potential Role of Government

Malaysian exporters need to know the standards relevant for their export markets and need to understand the standards' requirements as well as procedures of conformity assessment. One of the five lead agencies[2] designated by the government to coordinate assistance required by SMIs, the Ministry of International Trade and Industry, with the assistance of the Department of Standards Malaysia and SIRIM Sdn., can set up an information system that caters specifically for Malaysian exporters.

Measures to raise awareness of the importance and potential benefits of ISO 14000 contribute to an increased commitment of both government and industry. There is a strong need for training and capacity building related to EMS in Malaysia. Training should focus on representatives from government standards bodies, certification bodies, consultants, and industry leaders. Assistance could also include teaching material and curriculum development. The Ministry of Human Resources and the Ministry of Science, Technology and the Environment could provide such assistance in cooperation with the local universities and teaching institutions.

[2] Ministry of Finance for provision of financial assistance, Ministry of International Trade and Industry for market promotion and incentives, Ministry of Human Resources for skills training and management, Ministry of Science, Technology and Environment for technical assistance and research and development, Implementation Co-ordination Unit (ICU), Prime Minister's Department for infrastructure support (FMM, 1997)

The high costs of implementing the standard incurred by the SMIs should be subsidized and the funds should be provided by the Ministry of Finance.

Potential Role of Certified Industry

Certified industries in environmentally sensitive sectors have experience with environmental issues and are a valuable source of expertise for small organizations in developing countries. The large industries in Malaysia should be encouraged to provide consultation and assistance aimed at transfer of clean technologies and know-how, for example, in the form of visiting firm consultants or experience-sharing workshops. Cooperative strategies within the private sector, especially among SMIs, should be promoted and supported. Business associations and networks as well as chambers of commerce are a source of expertise and an avenue for communication which can help businesses identify the relevant environmental regulations and keep abreast of ongoing changes.

Mutual Recognition

Mutual-recognition between certification bodies in developed and developing countries for EMS would allow exporters in developing countries to benefit from their own certification infrastructures and to reduce costs. One prerequisite for mutual recognition is an existent standardization infrastructure in the developing country which can foster confidence of the importing country in the certification process.

There are several certification bodies in Malaysia and it is vital that these certifiers be credible in the international arena and their activities be quality controlled.

Participation in Standard Setting Process

Active participation in the standard-setting process allows developing countries to advance their interest and diminish any psychological barriers that may arise from the perception that the standards are imposed by industrialized countries. Malaysia has been an active participant in the TC 207 meetings and this has to be continued so as to bring forth the needs and interests relevant to the standards and Malaysian trade to the international community.

CONCLUSION

The SMIs play a vital role in the overall development of the Malaysian economy but unfortunately they are the main contributors to environmental degradation. The ISO standard on EMS has great potential in safeguarding the environment from industrial pollution in addition to providing opportunities for improving bottom-line benefits for industries. Though voluntary in nature, implementation of the ISO standard has various implications on Malaysian SMIs and the national trade. This paper has highlighted the possible negative and positive impacts of the standard on developing country trade. The paper has also suggested several measures that can be undertaken by Malaysia to ensure that the standard not become a trade barrier to Malaysian exporters especially SMIs. Such measures must will be considered by Malaysians in dealing with the opportunities and challenges posed by the ISO standards.

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