ISO 14000 as a Strategic Tool for Shipping and Shipbuilding.

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This paper reviews the ISO 14000 standards, especially the standards on environmental management, life cycle assessment and environmental performance evaluation. It presents examples of how ISO 14000 was implemented in Norwegian shipping and shipbuilding. These examples are the results from a research program in which four shipyards and one shipping company in Norway collaborated with the research foundation More Research. The holistic view and life cycle approach were essential to this research program. The environmental effects related to construction, operation and maintenance of ships were evaluated, and the results were presented by means of environmental performance indicators. The indicators were placed in a three-tier informational structure. Finally, it was demonstrated how the use of ISO 14000 as a complement to ISM can focus the shipping companies’ strategic efforts on areas which may yield the biggest economic returns for the future.

Nomenclature

ISO 14000. The standard for environmental management systems as stipulated by the International Organization for Standardization.
EMS. Environmental Management Systems.
EPE. Environmental Performance Evaluation.
LCA. Life Cycle Assessment.
EPI. Environmental Performance Indicators.
ECI. Environmental Condition Indicators.
LCC. Life Cycle Costing.
IMO. The International Maritime Organization.
dwt. deadweight tonnage.
gt. gross tonnage.

Introduction

During the past four decades, industrial environmental management views have shifted focus from the dilution of waste discharges to a focus on the environmental characteristics of the product itself. An increasing number of consumers demand environmentally friendly products and services that have little or no detrimental impact on the environment. The environmental impact of a product accumulates throughout its life cycle, with transport representing a major contribution to the total environmental load of a product. Environmentally friendly means of transport have therefore become an important element of competition and a new challenge to the entire transport industry.

“Good operational practice” is not sufficient to demonstrate a satisfactory environmental profile. The means of transport must (within practical and economic limitations) be made from environmentally friendly materials. Designing, building, maintaining and scrapping the transport means must be made with consideration to sustainability in every aspect of its life cycle.

ISO 14000 has become a challenge to Norwegian shipping and shipbuilding. Results from environmental management and life cycle projects in these industries are presented in this paper.

Norwegian Shipbuilding

Shipbuilding consists of small and medium sized enterprises along the Norwegian coast and constitutes approximately 3% of the world-wide ship building activities. New buildings in 1996 were 132,688 gt divided between approximately 30 shipyards [1].

Norwegian Shipping

Norwegian shipping operates within such sectors as supply, tank, gas, bulk, cruise, and fishery. The Norwegian foreign-going fleet had 1,382 vessels in 1996, or approximately 46.9 million dwt. This is 6.7 % of the world’s tonnage, or 3.7% of the world’s number of ships [1].

The System Life Cycle of a Ship.

The life cycle of a ship consists of four main phases: planning, construction, operation/maintenance and scrapping (see Figure 1).

Traditionally, the term shipbuilding encompasses the construction phase in the ship’s life cycle. Rebuilding is performed in the operational/maintenance phase. However, construction, maintenance and scrapping are all included in the business of shipbuilding.

Shipping is a very comprehensive business. One suggested definition is as follows: “Shipping is a complex

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international business involving international trade, multinational finance, insurance and investment, shipbroking and the management and operation of ships” [1]. It is debatable whether design activities belong to shipping or shipbuilding. Other parties belong more or less to both shipping and shipbuilding, such as insurance companies, financial institutions, and governments. ISO 14000 will be of consequence to them all.

The ISO 14000 Standards

ISO 14000 represents a new consensus position for the business and the environmental communities. It is a “package” tying the mandatory requirements of environmental performance to a management system. The standards have been designed for application by all organizations regardless of their size, process, economic situation or regulatory requirements.

The relationship between different ISO 14000 standards is shown in Figure 2. The most important ones for shipping and shipbuilding are the standards for Environmental Management Systems (EMS), Environmental Performance Evaluation (EPE) and Life Cycle Assessment (LCA). EMS and EPE are mainly oriented towards organizations or single companies. LCA, however, is product oriented and will therefore involve several companies. These three standards will be discussed in more detail below.

ISO 14001-04, Environmental Management Systems

ISO 14001-04 are the specifications of Environmental Management Systems (EMS) with guidance for use. The methodology for implementation of EMS consists of three main phases: planning (with identification of regulatory requirements), implementation (with commitment to continuous improvement), and regular evaluation of environmental performance. Implementation of EMS can be based on other management systems [2].

ISO 14031, Environmental Performance Evaluation

Environmental Performance Evaluation (EPE) provides for measuring environmental impacts that can be controlled by the organization. EPE is the process that organizations can use to measure, analyze, and assess their environmental performance against a set of criteria, and establish objectives and targets for improvements. EPE can be used by all organizations, with or without an EMS in place. EPE is an ongoing internal management process that uses environmental indicators to compare an organization’s past and present environmental performance with its performance criteria [3].

There are two basic evaluation areas to consider in selecting Environmental Performance Indicators (EPIs): the management area and the operational area. In addition, the condition of the environment is an evaluation area described by Environmental Condition Indicators (ECIs), see Figure 3. The condition of the environment covers the quality of air, water, soil, flora, fauna and human health. The operational area includes physical facilities and equipment, operation, and material and energy flows. Environmental related inputs and outputs to the management area include requirements, views of interested parties, information from the operational system, and information about the condition of the environment. EPE allows organizations to benchmark their performance against other similar organizations. The EPE process consists of several steps including
THE CONDITION OF THE ENVIRONMENT

Local

Regional

Global

THE ORGANIZATION’S EPIs

THE MANAGEMENT AREA

THE OPERATIONAL AREA

Input: materials, energy & services

Information flows

Output: products, services, wastes, emissions

Information flows

ISO 14040-14043, Life Cycle Assessment

Life Cycle Assessment (LCA) is a tool for evaluating the environmental impacts along the entire chain of a product’s life (from raw material extraction, through manufacture, distribution and transportation, use, recycling, and final disposition). The methodology includes the following:

1. Goal and scope definition
2. Inventory analysis
3. Impact assessment
4. Interpretation

During goal and scope definition, the application, depth and subject of the study must be defined. The functional unit and the system boundaries should also be specified. Inventory analysis is the stage in which emissions and raw material consumption from each process are identified. Impact assessment involves analyzing and assessing the effects of the environmental burdens identified in the inventory analysis. Finally, interpretation is the phase of an LCA in which a synthesis is drawn from the findings of either the inventory analysis, the impact assessment, or both. The findings of this interpretation phase may lead to conclusions and recommendations valuable to decisionmakers [4].

ISO 14000 and Conventions Given by the International Maritime Organization

Most ocean regulations pertaining to ships’ safety and environmental protection, are established by international conventions and protocols. The International Maritime Organization (IMO) is responsible for most requirements within international shipping. The most important conventions and codes are:

- Safety of Life at Sea (SOLAS)
- Prevention of Pollution from Ships (MARPOL)
- The International Safety Management Code (ISM)
- Safety and Environmental Protection (SEP)

The ISM system will affect all ships and all shipping companies over the next few years. It is specially devised for the safe management of shipping companies and ships and is expected to reduce the risk of human error. To succeed, the ISM code requires commitment from all levels in the company. Both ISO 14001 and ISM should be based on the top management’s formulated environmental policy which focuses on continual improvement, prevention of pollution, and compliance with rules and regulations. ISO 14001 emphasizes that an organization must identify its most significant environmental aspects, define objectives and targets for improvements of these, and develop management programs to reach these targets. ISM prescribes rules for the organization of a shipping company's management through the development of a Safety Management System (SMS). SMS is most concerned with the safety and security systems of the ship and the environmental impacts caused by accidents during the operation phase. Thus, the scope of the ISO 14000 standards are broader than the ISM code. It is not enough to only follow ISM if the environmental friendliness of a ship is to be documented. It is necessary to document the ship’s environmental impact within each phase of the ship’s life cycle to be sure that the environmental performance of the ship is as good as possible (within economic and technical limitations). This can be achieved by adopting the ISO 14000 standards as discussed in the next section.

Examples from the Application of ISO 14000 in Norwegian Shipping and Shipbuilding

Figure 4 illustrates the structure of the program called “Environmental Management in a Life Cycle Perspective”. The program is divided into three parts:

- The implementation of EMS at shipyards
- Development of EPIs and EPE appropriate for shipyards
- LCA and Life Cycle Costing (LCC) for selected parts of a ship

Five companies (three construction yards, one maintenance and repair yard, and one shipping company) have collaborated with the research foundation More Research in Norway.
EMS and Shipbuilding

The shipyards involved in the program have partly implemented an EMS, mainly the three first steps in the ISO 14001 procedures:

1. Environmental policies are described.
2. Environmental aspects are identified relative to external material protection, waste treatment and section mounting.
3. Objectives and targets are established, e.g. better utilization of available 'surplus energy'; reducing the percentage of wastes; assessing environmental effects by covering up the ship during painting and sandblasting; routine improvement in treating special wastes; and developing action plans.

One example of an environmental policy statement from a Norwegian shipyard is as follows:

In 1994 [the company] joined in with the pronouncement of a sustainable development made by the International Chamber of Commerce (ICC). This implies an ambition of building ships with a minimum of environmental impact in a life cycle perspective:

- give priority to the sustainable development perspective when selecting materials and components,
- advance the yard towards the most favorable working environment, minimize emissions and discharges,
- operate the yard according to the needs of the society, the laws and legislation,
- give priority to an open dialogue with the employees, the local community and the authorities.

Even though the EMS was not fully implemented by the shipyards, good environmental performance has already provided economic gains and positive environmental effects. It has been demonstrated that recycling of thinner has compensated for approximately NOK 100,000 annually and environmental savings in reduced wastes at about 5,000 liters annually (90-97 % reduction annually) [5]. Similarly, better waste management procedures have brought about a reduction of approximately 30 % of the waste at shipyards.

EMS and Shipping

Today there are no shipping companies in Norway with an implemented EMS according to the ISO-14001 standard. In fact, the Norwegian Shipowners Association and some shipowners hope that ISO 14000 will have no significant consequences for shipping, as most of those having involved themselves in ISO 9000 still struggle with this [6]. However, some shipping companies focus on good environmental management practice such as:

- Coating systems without organotin
- Cooling water systems to prevent growing of hull instead of using antigrowing paint system
- Waste handling systems on board their ships
- Educating employees on ships in environmental issues and attitudes

EPE and the Development of EPIs/ECIs in Norwegian Shipbuilding

The use of EPIs and ECIs is new for the Norwegian shipbuilding industry. One method for identification and implementation of EPIs was tested for the first time at some shipyards [6]. The main focus when selecting EPIs was production, even though one yard focused also on the distribution of the steel prior to hull assembly.

A good structure of EPIs is based on 3 levels of information, see Figure 5. Each of the shipyards involved in the research program is a part of a conglomerate comprising other shipyards. This makes a three-tier informational structure appropriate.

The reporting parameters at the lowest level are used for measuring the environmental standings on a short term basis, and are management tools for every day issues. This information is meant to be used for communication both within the company and to the stakeholders. The reporting parameters might be further aggregated to EPIs and indices in order to compare the company’s real environmental performance with the environmental targets set for the period.

A set of indices, EPIs, and reporting parameters for main shipyard activities were suggested as illustrated in Table 1. They were developed for validity within defined system boundaries. With a standard way of calculating
Environmental performance scores, it is possible to benchmark companies within a trade. However, such comparisons must be carried out carefully; it is important that companies use the same basis for these calculations.

Table 1  Appropriate EPIs for shipbuilding.

<table>
<thead>
<tr>
<th>Corporate level</th>
<th>Index</th>
<th>External material protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material use</td>
<td>Index</td>
<td>Local management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Indicators</td>
</tr>
<tr>
<td>• Material utilization</td>
<td>• Emission of noise</td>
<td></td>
</tr>
<tr>
<td>• Energy use per unity of material</td>
<td>• Emission of dust</td>
<td></td>
</tr>
<tr>
<td>• Emissions of solvent</td>
<td>• Use of paint per unit area</td>
<td></td>
</tr>
<tr>
<td>• Use of paint per unit area</td>
<td></td>
<td>Reporting parameters</td>
</tr>
<tr>
<td>• Percentage excess material</td>
<td>• Number of complaints on noise from neighbors</td>
<td></td>
</tr>
<tr>
<td>• Purchase of cut steel plates</td>
<td>• Degree of covering when sand blasting or painting occurs</td>
<td></td>
</tr>
<tr>
<td>• Purchase of complete hulls</td>
<td>• Amount of generated dust per ton spent blasting sand</td>
<td></td>
</tr>
<tr>
<td>• Transport of material (t⋅km)</td>
<td>• Recycling of thinner</td>
<td></td>
</tr>
<tr>
<td>• Means of transportation from the steelworks to the yard</td>
<td>• Number of accidentally painted cars</td>
<td></td>
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</tbody>
</table>

Examples of EPIs:
- Material utilization = 1 - \[\frac{\text{Weight of excess material}}{\text{Total weight of steel product}}\]
- Emission of noise (or dust) = Measured emissions (dB or g/m³) 100 m from the site of sandblasting

EPE, EPIs and Shipping

EPIs may be selected for each subsystem of a ship. For example, for the main engine systems, EPIs can be structured as illustrated in Table 2. Similarly, EPIs can be developed for other subsystems like the hull, the equipment, the waste handling systems, etc. By means of target levels for different types of emissions, the ship’s true emission performance can be measured by EPIs.

Table 2  EPIs for main engine system.

<table>
<thead>
<tr>
<th>Indices</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• Contribution to global warming potential</td>
<td></td>
</tr>
<tr>
<td>• Contribution to acidification</td>
<td></td>
</tr>
<tr>
<td>• Contribution to eutrophication</td>
<td></td>
</tr>
<tr>
<td>• Contribution to smog formation</td>
<td></td>
</tr>
<tr>
<td>• Material efficiency</td>
<td></td>
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</tbody>
</table>

EPE and Indicators for Other Evaluation Areas

So far, this paper has discussed EPIs related to the operational area in an organization or to the ship system. Suggested indicators for performance evaluation within the management area and for the condition of the environment are:

Management area
- Financial performance
- Community relations
- Implementation of policies and programs
- Conformance with legislation

Condition of the environment (local, regional, global)
- Quality of air, water, soil
- Number of species in flora (or fauna)

EPE, EPIs and Other Interested Parties within the Maritime Industry

An interesting issue is to find adequate EPIs for communication between the shipbuilding industry and the shipping industry. Since the designer/consulting companies, the scrapping yards, and recycling plants are not clearly defined as a part of either the shipping industry or the shipbuilding industry, it is important to find EPIs also for communication among them. The group of stakeholders within the maritime industry is illustrated in Figure 6.
LCA, Shipbuilding and Shipping

In most LCA-studies, the life cycle starts with raw material extraction, and culminates with the final disposal or recycled material, i.e. the “cradle to grave” approach. Within shipping, the life cycle concept is often understood as the period from the time the ship is contracted until the time it is sold. Assessment of the economic life cycle focuses on the trading profit. Since the understanding of the life cycle within shipping is mainly restricted to the operational phase, it is in conflict with what is defined as the life cycle of a product according to the LCA-standard. For example, the life cycle of the steel part of a ship may be illustrated by Figure 7. Steel enters the system life cycle of the ship in the construction phase. The environmental impact caused by steel parts depends on the raw material extraction, processes cutting and fitting of steel plates and profiles, mounting of plates to sections by welding, grinding, sand blasting and painting, and transportation of steel components and sections.

In the research program carried out at Norwegian shipyards, the flow of materials were determined quantitatively, and the data were related to a functional unit such as “1 ton steel”. Different patterns of steel flows from steelworks to shipyard were evaluated. By using today’s practice with several vendors and transportation between the steelworks, suppliers and the shipyards, the environmental impacts were evaluated by means of the LCA software tool SimaPro [8]. The SimaPro software evaluates data to demonstrate how different substances contribute to global warming, ozone depletion, acidification, eutrophication, smog formation and pollution caused by heavy metal discharges to the environment. For an alternative scenario, in which cut steel plates were transported directly from the steelworks to the shipyard, the environmental impacts were reduced due to less transportation and material consumption. The results showed lower emissions of greenhouse gasses, lower regional acidification and eutrophication effects and lower emissions of substances causing smog formation [7].

Fig. 6 Stakeholders within the maritime industry.

Fig. 7 The life cycle of the steel part of a ship.

Similarly, the fuel system’s entrance into the system life cycle of the ship may be as illustrated by Figure 8. By a calculated average fuel consumption of 15 g/t-km and emission factors given in Table 3 [6], the environmental impact from a ten year period of a platform supply vessel operating in the North Sea were evaluated. The results show that acidification effects dominate as the most serious. The study is combined with an LCC analysis.
The results of the LCA/LCC conducted in the research program have shown the following:

- Change from Marine Gas Oil (MGO) to Heavy Fuel Oil (HFO) leads to increased emissions of acidifying gasses. The change from MGO to HFO also increased fuel consumption and maintenance costs, but reduced operational costs [9]. MGO is found to be a better fuel alternative than HFO, both from an economic and environmental point of view.

The information the LCA provides will be an important input to the ship designer. However, software is needed to analyze and evaluate multivariable environmental issues.

### Summary and Conclusions

ISO 14001 is a supplement to the ISM-code. The intention of ISO 14001 is to promote proactive attitudes towards environmental improvement actions within companies. So far ISO 14001 has resulted in models for EMS at shipyards. Shipyards with a good environmental management practice have reduced their environmental loads through better planning. They have achieved economic return from increased efficiency of resource use and waste treatment practice. Shipyards have also realized benefits in credit approval. However, they have also incurred higher management costs in the planning stage.

Some consequences of ISO 14001 for shipbuilding in the future may be:

- Increased knowledge about environmental issues and performance
- Better conditions for loans and insurance
- Cost savings through better resource utilization
- Better reputation in the local community
- Procedures for continuous improvement and a code of practice for shipyards
- Better health and safety conditions at yards resulting in better recruiting of labor to the industry

ISO 14031 and EPIs will be important tools for communicating environmental performance among...
interested parties and groups within industrial clusters such as the maritime cluster. EPIs will also be of importance for benchmarking, but probably not in the near future.

ISO 14040-standards have already provided data input to ship design and improvement of maintenance routines. It has contributed to optimization of fuel consumption and bottom hull coating and to cost/environmental optimizations for the vessel taken under study. Today there are still no examples of complete LCAs for ships. However, some examples are available for parts of ships.

The results from an LCA/LCC should be a strategic tool for policy- and decision making, and a tool for highlighting important connections between materials, environment and costs throughout the life cycle of a ship. The results must be addressed to ship owners, shipbuilders, ship designers, and suppliers in order to improve and optimize design, maintenance routines, fuel consumption and machinery performance. The information will aid the planning of the ship owners environmental and economical goals, aid subcontractors in setting new requirements, and enable better compliance with legislation. Examples of the positive effects caused by correct environmental measures, are reduced maintenance, service and fuel costs, and hopefully longer life-cycle and higher second hand or demanufacturing value. The results of an LCA/LCC will be important in the achievement of sufficient information for setting the right priorities.

Some recommendations for future use of the ISO 14000 standards as strategic tools within the business of shipping and of shipbuilding are:

- Use the ISO 14000 standards to develop environmental profiles for different scenarios of a ship’s performance during its entire life cycle
- Harmonize ISO 14001 with the ISM-Code
- Develop EPIs (after the ISO 14031 standard) that reflect requirements that will be enforced in the ship industry in the future, and practice the use of relevant EPIs as reporting parameters to and among interested parties
- Use ISO 14040-43 in combination with “Design for Environment” principles in the early planning of ships

Note however, that the lack of information on scrapping activities throughout the world makes it difficult to measure total environmental impact. To gather sufficient information on these activities is a challenge. Another important challenge is to develop weighting models and specific environmental performance evaluation criteria for selected oceans areas.

To get ISO 14000 implemented in the shipbuilding and shipping industry there will be a need for closer cooperation and communication between the different parties involved in the different phases of the ship’s life cycle (designers, construction yards, ship operators, maintenance and repair yards, supporters and suppliers, financial institutions, scrapping yards and waste handling and recycling companies, etc.) ISO 14000 can be used to develop the industry standard for environmental performance evaluation within the maritime industry. Networks will strengthen by setting forward mutual requirements among the involved parties within the industry. That will be an additional important competitive factor for shipping and shipbuilding in the transport market.

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