ASPECTS IDENTIFICATION AND IMPACTS EVALUATION IN ENVIRONMENTAL MANAGEMENT SYSTEMS

- A CASE STUDY USING THE FMEA APPROACH

by

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DEDICATION

To my wife Anne, with love and gratitude

ABSTRACT

This thesis is a description of how environmental aspects are identified and evaluated using a case study to illustrate the application. It describes the mechanics using a four-step sequence.

The first step is selecting the target organisation. The second step is identifying the full range of environmental aspects of the target organisation. The third step is evaluating the aspects to determine their impacts on the environment and rating each aspect against suitable criteria. The final step is selecting the significant aspects. Significant aspects will become the focus of the organisation's continuous improvement efforts.

A systematic methodology of identification was evolved in the case study and is documented here. In addition, the FMEA approach, which was used to rate aspects, is described and illustrated.

The thesis expands on the mechanical process of aspects identification and evaluation to describe operational issues that affect the qualification of aspect identification and evaluation. The discussion takes in points observed during the case study and the evolving operations management perspective on environmental aspects.

As a follow on to the case study the same methodology was adopted and applied to two other cases. These cases were used for a comparison with the case study and to prove that the described methodology is transferable. This was proven. The further applications allowed for quantitative and qualitative comparisons to be made.

ACKNOWLEDGEMENTS

I wish to thank Donnelly Mirrors Ltd. for providing me with the opportunity to study the subject matter of this thesis and for allowing me to use material and experiences from the Company's two Irish sites. In particular, I wish to thank Mr Dave Watson, the company's Chief Executive and Mr Brian McNamara, Process Engineer and Environmental Officer.

In addition, I wish to thank Thermo King Europe Ltd. for allowing me to use material from their facility as an extension to the case study. Mr John Lane and Ms Yvonne Brennan were extremely helpful.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

Many writers on the subject of Environmental Management Systems (EMS) have commented on the difficulties associated with identifying environmental aspects and evaluating their respective impacts on the environment. Difficulties include creating a procedure that is inclusive, systematic and that objectively ranks aspects in order of significance and in keeping with the criteria in the Standard. This document proposes to address those difficulties by outlining a systematic approach for aspects identification and impacts evaluation. The methodology was developed in a case study and was successfully repeated. The scope of the document is to describe the methodology and its application using the case study for illustration. Two further cases are brought into the discussion where the methodology was repeated along with some benchmark material.

The discussion is taken from an operations management as opposed to from a strictly environmental perspective. Operations managers are responsible for their site activities, not environmental specialists or subordinates. While technical and administrative responsibility may be delegated, the overall responsibility for the EMS and site-specific environmental issues remains with that function. Identifying and evaluating environmental aspects is one of the 'foundation steps' in implementing an EMS. A practical, inclusive and effective methodology of approaching the exercise is required - what to do and how to do it. It is therefore important to consider this difficult and important task using the operations manager's terms of reference. General guidelines on what to consider and include are contained in ISO 14001 and ISO 14004. Information on how to apply those guidelines is not readily available. Having good guidelines and benchmarks are essential for effective and efficient implementation. The writer has an operations background.

Difficulty was experienced in coming up with a practical methodology (i.e. one that is systematic, inclusive and cost effective) of addressing aspects identification / impacts evaluation. It is this difficulty that EMS writers have commented on. Given the lack of material outlining aspects identification / impacts evaluation in the field, this document is aimed to be a help to environmental and non environmental specialists faced with installing an EMS rather than as a critique of approaches. Faced with a live situation the writer had to make choices, adopt an approach, follow it through and submit it to the challenge of appraisal by registered auditors. The synthesis of the approach and further application to other cases is the main theme of this document.

The company on which the initial case study was based is Donnelly Mirrors Ltd. It is an automotive mirror manufacturer established in Ireland for over thirty years. The company is a scheduled activity[1]. Appendix 1 is an extract from the company's published Annual Environmental Report for 1999 and it is included as an introduction to the company.

In 1999 the writer was actively engaged in preparing the subject company for meeting the requirements of ISO 14001. It became clear that the aspects identification / impacts evaluation which had been done was inadequate and was flawed both in scope and application. Items indicated by the Standard were omitted and the evaluation mechanism was not robust. The writer set about establishing a systematic and inclusive methodology and used this for re-identification and re-evaluation of the aspects and impacts respectively. The company was assessed for ISO 14001 and was recommended for the Standard.

Since then the writer applied the same methodology to a sister plant (Donnelly Vision Systems, Ltd.). This allowed the methodology to be tested further. Furthermore, a third party

[1] It is described by one of the definitions of activities in Schedule 1 of the Environmental Protection Agency Act, 1992 and must therefore have an Integrated Pollution Control (IPC) Licence

company (Thermo King Europe Ltd.) took the model, amended it and used it successfully. The experience and comparisons of the three applications has given the writer the opportunity to develop and assess the scope, applicability and transferability of the methodology.

The aim of this dissertation is to outline the approach to aspects identification and evaluation and to discuss this from an operations management perspective. The method used in the case study is described. Observations and experiences from the case study are reviewed. The operations management perspective is brought out and discussed. Comparisons are made between the three applications cases. Finally the method of approach is summarised along with a summary of guidance points gained from the experience.

SECTION 1

ENVIRONMENTAL MANAGEMENT SYSTEMS AND ASPECTS

1.1 ENVIRONMENTAL MANAGEMENT SYSTEMS AND ASPECTS

An Environmental Management System (EMS) is a methodology for systematically addressing environmental performance improvement. It is a management tool for improving environmental performance, not a measure of performance. Two standards are in use: I.S. EN ISO 14001 and EMAS[1]. Both are formal as opposed to informal systems. Both require assessment by registered third party assessors. An informal system is an unregistered in-house system. It can be used, for example, to support the EMP[2] requirement of an IPC[3] license.

ISO 14001 defines an EMS as *'that part of the overall management system that includes organisational structure, planning, activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy'*. Both standards require that the policy must be site specific and show commitment to continuous improvement. Therefore site specific environmental issues must be identified and measured in order to have a meaningful base line for continuous improvement. The register of aspects helps to perform this function. ISO 14001 does not specifically call for a register of aspects, unlike EMAS. It calls for the identification of significant aspects. However, as cycles of continuous improvement and operational change revise the relative significance of aspects it is advisable to keep a register of aspects.

Using ISO 14001, Fig 1.1 shows how the sections of the standard move along the 'plan, do, check, act' stages of the continuous improvement[4] sequence, repeatedly. This thesis is focused

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[1] The Eco-management and Audit Scheme (EMAS)

[2] An Environmental Management Programme (EMP) contains most elements of an EMS but is not accredited.

[3] An Integrated Pollution Control Licence (IPC) is a formal document of legal standing that outlines environmental performance criteria (e.g. emission limits) in a scheduled activity (i.e. an activity as defined by Schedule 1 of the Environmental Protection Agency Act, 1992)

[4] The Plan, Do, Check, Act cycle is known as the Deming continuous improvement cycle after Dr Deming.

on section 4.3.1 of ISO 14001, which is the Environmental Aspects stage of the 'Planning' phase. Environmental 'aspect' and 'impact' are defined by ISO 14001 as:

Aspect: *"element of an organisation's activities, products or services that can interact with the environment".*

Impact: *"Any change to the environment whether adverse or beneficial, wholly or partially resulting from an organisation's activities, products or services"*

ISO 14001:1996(E) Annex A refers to the cycle in Fig. 1.1 as the dynamic cyclical process of "plan, implement, check and review". Stafford, writing for the EPA described the loop as thinking, planning, doing and measuring. (Bouchier, Higgins and Walsh, 1998). Environmental aspects identification and evaluation is necessary to plan an EMS.

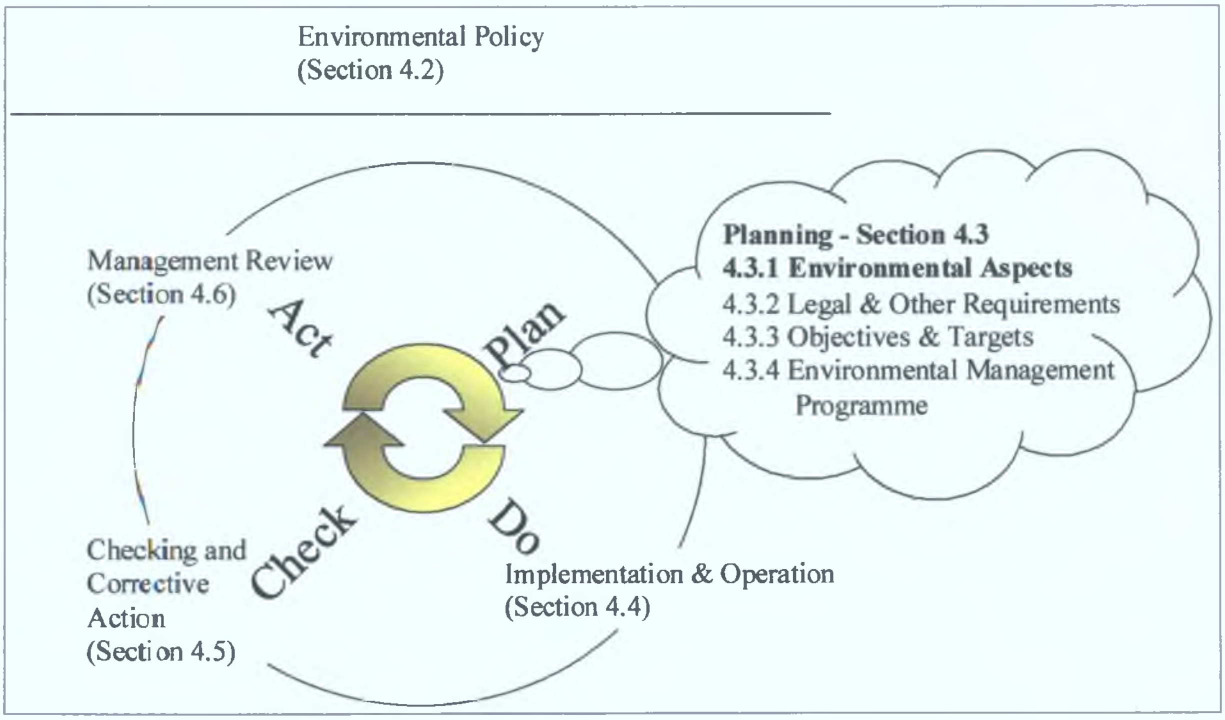

Fig 1.1 The Cyclical Nature of an EMS – using ISO 14001 to illustrate and to highlight the position of aspects identification/evaluation in the process

An example of an aspect would be a painting process in a manufacturing plant that uses many tonnes of paint in a year to paint product. That aspect might have several environmental impacts. For example, one direct impact would be the effects on local flora, fauna, soil and groundwater from the volatiles of the paint (VOC) escaping from the plant and coming to ground nearby. Another impact would be the effect on employees or neighbours (humans are included in the ISO 14001 definition of the environment). An indirect impact might be noise from delivery vehicles.

1.2 WHAT WRITERS HAVE SAID ABOUT ENVIRONMENTAL ASPECTS

- [Environmental Aspects] *is without doubt the most important part of the Standard. All the other elements are linked to this fundamental concept. It is the area where the implementing organization must spend most time.* (Whitelaw, 1997).
- *"All other system elements are based on the environmental impacts that the organisation has identified and deemed significant. ...This is therefore one of the most critical and unfortunately, most difficult requirements of an EMS to implement."* (Jackson, 1997).
- *"Impacts identification and evaluation are the most difficult part of an EMS*" (Bouchier, Higgins and Walsh, 1998).
- *Organizations that complete their aspects evaluation in an unstructured manner do so at their peril and may face difficulties during full implementation of the system.* (Latham, 1999).
- *ISO 14001 also suffers from a limited global uptake due to the inaccessibility of some of its terminology. What is a significant environmental aspect and how do you assess its significance?* (Carter and Wood, 2000).

1.3 RESEARCH AND LITERATURE REVIEW FOR THE CASE STUDY

Research was restricted by the nature of the subject and was confined to secondary sources for the most part. Restrictions included the reluctance of companies to discuss their aspects in any detail for business and litigation reasons. The standard is vague. As commented by Carter, a member of ISO technical committee ISO TC 207 SC/2, *"...in meeting demands of translation and the avoidance of too much disclosure the wording of the standard has become economic and vague."* (Carter *et al*, 2000). Research was confined to interpretation of the standard, guidelines, secondary research material and to the interpretation of the application of the Standard to a live and challenging case study. Ad hoc sources of information included training material and comments from industry practitioners and experienced auditors.

SECTION 2

CASE STUDY APPLICATION

2.1 CASE STUDY SCOPE AND ISO 14001

One of the first decisions faced by an operations manager is what standard to apply: ISO 14001 or EMAS? In the case study this was given by corporate policy; all manufacturing sites would become ISO 14001 registered.

A second consideration is the scope of the application – what ISO 14001 will apply to, how extensive this might be and where to start. The Standard can be applied to all of or to specific operating units of an organisation. Annex A of ISO 14001:1996(E) states *that "An organization with no existing environmental management system should, initially, establish its current position with regard to the environment by means of a review. The aim should be to consider all environmental aspects of the organization as a basis for establishing the environmental management system."* Aspects / impacts identification and evaluation is a major part of the initial environmental review as well as being an ongoing requirement under ISO 14001 (Section 4.3.1). A further consideration is that since the policy must be site specific, knowledge of the aspects and their associated impacts would facilitate a meaningful policy document.

The case study is a scheduled activity (Schedule 1 of the Environmental Protection Agency Act, 1992) and has a class 12.2[1] Integrated Pollution Control licence. The IPC licence application and support material is considered to be an Initial Environmental Review (IER)[2]. Work had been done to remain in keeping with Condition 2.1 of the licence; *"The licensee shall establish and maintain an Environmental Management System (EMS) which shall fulfil*

[1] This class (12.2) is for organisations that "…manufacture or use coating materials in processes with a capacity to make or use at least 10 tonnes per year of organic solvents…" [quoted from the Act}

[2] This is also called 'Preliminary Environmental Review' (PER)

the requirements of this licence". In this case the licensee had proposed to the EPA that it would seek to establish ISO 14001 in keeping with Condition 2 of its licence. As this was a scheduled activity with an established licence there was the benefit from the review activity that had been done for the licence application. There was also an established environmental management system for the licence (though not accredited). Non-scheduled activities would not have the benefit of such groundwork.

A third consideration for aspects identification / impacts evaluation is the criteria the Standard specifies. Note that Annex A of ISO 14001:1996(E) states *"The level of detail and complexity of the environmental management system, the extent of documentation and the resources devoted to it will be dependent on the size of an organisation and the nature of its activities."* The Standard requires organisations to *"...establish and maintain (a) procedure(s) to identify the environmental aspects of its activities, products or services that it can control and over which it can be expected to have an influence...".* The procedure(s) should use the aspects identification phase to establish what significant impacts there are, or could be from the aspects and these should be considered for setting environmental objectives. While the Standard indicates that a balance should be struck between the level of detail, complexity, documentation and resources against the size and nature of the organisation it also specifies a far-reaching range of criteria to be considered. The criteria are multi-dimensional and include consideration of past, present, future, normal, abnormal, emergency, direct, indirect and cumulative effects in the operating conditions (see Fig. 2.1). The challenge for the case study application was to successfully integrate all of these multi-dimensional requirements into a robust systematic approach that can be successfully repeated and which strikes a balance between cost (i.e. resource deployment) and effectiveness. As the methodology would be transferable it should complement the cost/size balance concept and be repeatable.

The balances to be struck – completeness : cost and resources

'The Standard places much emphasis on the word significant and the judgement of significance is a critical issue, which bears upon a fundamental conflict between, on the one hand, the need to insure that important aspects are not overlooked by cursory assessment and, on the other hand, the need to pay attention and assign resources to those aspects which are truly important.' (Whitelaw, 1997)

'An organisation with no existing environmental management system should, initially, establish its current position with regard to the environment by means of a review. The aim should be to consider all environmental aspects of the organisation as a basis for establishing the environmental management system.' (ISO 14001:1996(E), Annex A)

Organisations should determine what their environmental aspects are, taking into account the inputs and outputs associated with their current and relevant past activities, products and/or services. (ISO 14001:1996(E), Annex A)

In all cases, consideration should be given to normal and abnormal operations within the organisation, and to potential emergency conditions. (ISO 14001:1996(E), Annex A)

The process to identify the significant environmental aspects associated with the activities at operating units should, where relevant, consider,

a) emissions to air;

b) releases to water;

c) waste management;

d) contamination of land

e) use of raw materials and natural resources;

f) other environmental and community issues

This process should consider normal operating conditions, shut-down and start up conditions, as well as the realistic potential significant impacts associated with reasonably foreseeable or emergency situations. (ISO 14001:1996(E), Annex A)

The organisation shall keep this [environmental aspects register] *up-to-date.'* (ISO 14001:1996(E))

'The level of detail and complexity of the environmental management system, the extent of documentation and the resources devoted to it will be dependent on the size of an organisation and the nature of its activities.' (ISO 14001:1996(E), Annex A)

The (significant) aspects identification process *'... should take into account the cost and time of undertaking the analysis and the availability of resources.'* (ISO 14001:1996(E), Annex A)

'Organisations do not have to evaluate each product, component or raw material input. They may select categories of activities, products or services to identify those aspects most likely to have a significant impact' (ISO 14001:1996(E), Annex A)

Fig. 2.1 The Balance Between Cost and Effectiveness in the Environmental Aspects Stage of ISO 14001

The case study challenge was to devise a methodology to tackle the problem systematically.

2.2 THE ASPECTS IDENTIFICATION AND EVALUATION PROCESS

2.2.1 The Steps in the Process

The first major challenge of aspects identification / evaluation is to understand the systematic steps necessary to complete the process. Grimes suggests that *'irrespective of the standard, the process* [of identification and evaluation of impacts] *can be dealt with in four steps:*

> *Step 1: involves the selection of an activity, product or service for further examination.*
>
> *Step 2: generation of an exhaustive list of all associated aspects and impacts.*
>
> *Step 3: assessment of the significance of identified aspects and impacts.*
>
> *Step 4: establishment and maintenance of a 'register' or list of significant aspects.'* (Grimes, 1999).

A similar four-step process is recommended under ISO 14004. This is another ISO 14000 series standard. It is a guideline to support the Standard itself (ISO 14001) and the Annex to ISO 14001. For example ISO 14015 (Environmental Management – Environmental assessment of sites and organisations [EASO]), which is still in committee draft (CD) form and unpublished, will specify aspects identification and evaluation for new premises. ISO 14015 is not intended for use as a specification standard for certification or registration purposes. The steps that ISO 14004 recommends for aspects identification and evaluation are as follows:

1 Select an activity or process

2 Identify environmental aspects of the activity or process

3 Identify environmental impacts

4 Evaluate significance of impacts

The above four steps can be loosely summarised as selection, identification, evaluation and documentation. That sequence was applied to the case study as shown in Fig 2.2.

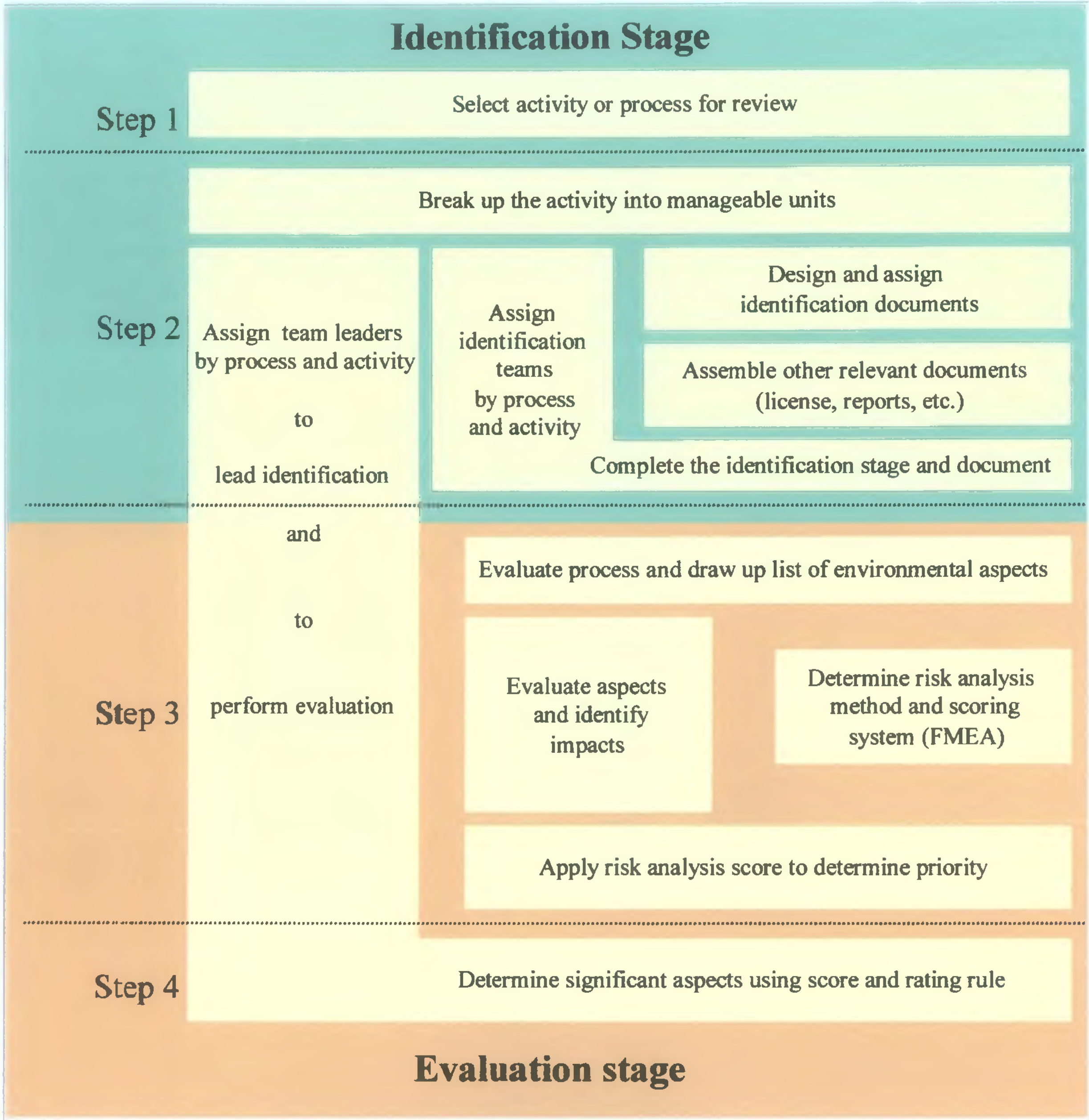

Fig. 2.2 The Aspects Identification and Evaluation Process – Case Study Application

2.2.2 Step 1. – Selection of Activity or Process

This is step 1 according to ISO 14004 and Grimes (Grimes, 1999). As the application in the case study was to be to a manufacturing site, selection would be all of the activities, products and services on the site. A consideration not catered for in the Standard or associated guidelines is how to ensure that all activities, products and services are included systematically.

2.2.3 Step 2. – Identification of Aspects

Aspects are identified before impacts, as the aspect is responsible for the impact. The method should identify aspects in a way that would systematically include all activities, products and services and all of the multi-dimensional requirements specified in the Standard. This is a complex undertaking given the diversity of the organisation and the multi-dimensional requirements of the Standard. After consideration the following identification stages were defined:

1. Break all of the activities up into manageable units, using a divergent 'bottom up' approach for identification to support a convergent top down approach for evaluation.
2. Use teams of internal experts to identify the 'elements that can interact with the environment'.
3. Use structured documents to guide the teams and to facilitate a systematic, iterative approach, which should integrate all the multi-dimensional criteria in the Standard.
4. Complete the identification stage with a focus on completeness of identification and generation of data in an organised format that would facilitate the later stage of environmental impact evaluation.
5. Document the identification stage.

2.2.3.1 Breaking the Activity into Manageable Units

Twelve homogenous process areas/activities were identified in the case study as shown in Table 2.1 below. These were selected to include all of the activities, products and services on site. Activities were both active (e.g. manufacturing) and passive (e.g. facilities services).

2.2.3.2 Selecting Representative Teams

For the areas/activities, twelve cross-functional teams were identified with a team leader that would be a link through the whole process. The facilities manager and environmental officer fulfilled this role and overlapped on two teams in order to maintain consistency. Each area/activity could be looked at as an entity of its own with its own special features and support groups. The teams for each area would be able to identify the multi-dimensional features of their respective areas/activities. In the case-study the cross functionality of the teams linked knowledge of prevailing operations practice, technical control, past practice and future plans in addition to indirect and abnormal activity. The teams make up that were compiled to carry out the review are shown in table 2.1 below.

Aspects Review Teams – Case Study Application			
No	**Aspects Area**	**Leader**	**Team**
1	Materials and waste	**Environmental officer**	Supervisor, scheduler
2	Hazardous materials and waste	**Environmental officer**	Effluent plant operator, design engineer
3	Silvering process	**Environmental officer**	Production manager, engineer, team leader, **facilities manager**
4	Prism manufacturing	**Facilities manager**	Production manager, engineering manager, engineer
5	EC manufacturing	**Environmental officer**	Engineer, team leader (2), operator
6	Cell build assembly	**Environmental officer**	Supervisor (2), engineer, operator
7	AFM assembly	**Facilities manager**	Engineer, supervisor, operator
8	Moulding / mirror assembly	**Facilities manager**	Production manager, team leader
9	Facilities	**Facilities manager**	Maintenance manager, I.T. manager, laboratory manager,
10	Effluent treatment plant	**Facilities manager**	**Environmental officer,** effluent plant operator
11	Supply side	**Environmental officer**	Purchasing officers (x3)
12	Grounds, site, etc.	**Facilities manager**	Maintenance manager, grounds man

Table. 2.1 Case Study Teams for Aspects Identification

2.2.3.3 Constructing Suitable Structured Documents for the Review

What documents would be suitable to capture the information in a well-organised manner for each of the twelve areas? For processes (e.g. silver line), it was decided that flow charts would capture and describe the processes in their logical stages and in sequence. Some detailed flow charts existed in the organisation but these were too detailed in some ways (product specific - down to the last fastener) and not broad enough to describe the full scope of the process (e.g. no product on its own used all the possibilities of the process). For passive activities (e.g. grounds, site, etc.) block diagrams would provide a suitable break down. It was therefore decided to construct generic flow charts and block diagrams for the aspects identification / evaluation exercise. Column matrices with standard column headings were designed to complement the flow charts and block diagrams. The column matrix was designed to allow the multi-dimensional requirements of the Standard to be considered for each sub-process of the flow chart for all of the environmental media. For ease of use the documents were constructed for use in A4 format. Trial and error resulted in nine column headings across the matrix. These were used to assess the sub processes of the flow chart. Designed into the column headings was the provision to meet the scope of the definition of 'environment' as given by the Standard. i.e. '*surroundings in which an organisation operates, including air, water, land, natural resources, flora, fauna, humans, and their interrelation.*' (ISO 14001, 1996). Note the inclusion of 'humans' in the definition. This is catered for in column seven, under Occupational Health and Safety (OHS). The matrix is used to identify and summarise process and activity issues in an aspects identification format. Fig 2.3 shows the construction of the matrix.

Reference	1	2	3	4	5	6	7	8	9
Sub-Process	**Energy & Resources**	**Water Use & Aeq' discharge**	**Air Emissions**	**Hazardous Materials & Waste**	**Normal Waste (s&f)**	**Indirect**	**Noise, OHS & Nuisance**	**Recycle, Land, Eco-sys,**	**Design (or others)**
Sub-process 1									
Sub-process 2									
Sub-process 3									
Etc.									

Fig 2.3 The Aspects Identification Matrix

The reference column gives the sub-processes or block descriptions that are evaluated across the row. The other columns, 1 to 9, are the lists identified under the nine headings:

1. List any materials or energy consumption associated with the sub-process.
2. List any water usage or water emissions.
3. List any air emissions including dust.
4. List any hazardous materials, suspected hazardous materials or any hazardous wastes associated with the process for that sub-heading. Hazardous waste is waste specified as List I and List II of EC Directives 74/464/EEC & 80/68/EEC and Annex II of the Council Directive on Hazardous Waste 91/689/EEC directives. The team leaders were familiar with those Lists and Annex and were competent to judge what was hazardous. The criterion for the Pollution Emission Register was used. That is given in the Guidance Note for Annual Environmental Report, published by the EPA. In addition to specifying the above lists and Annex, the Guidance Note states there is no threshold for reporting. Therefore any amounts, no matter how small should be included. Both team leaders were

familiar with the company's Pollution Emission Register and were able to make judgements in the exercise.

5. List any normal (non-hazardous) waste materials, particularly packaging. Waste is any substance or object that the holder disposes of or is required to dispose of.
6. List any indirect activities associated with the sub-process (e.g. maintenance of equipment is an indirect activity associated with the direct activity of using the equipment). Indirect items will be considered as separate items under all nine headings at the end of the evaluation of direct sub-processes. This is a method of capturing all associated indirect activities.
7. List any environmental noise, nuisance or OHS issues associated with the sub-process.
8. List any land, eco-system or site effects. Include in this category any opportunity for recycling.
9. This heading is used to consider if there are any environmental design implications or environmental improvement potential. It is also used as a catchall if anything does not neatly fit one of the categories.

By looking at all direct operations, activities and physical support systems on the site in the above manner it is possible to identify all associated direct aspects. Using the same method, matrix and headers the indirect, abnormal and emergency conditions can also be identified across the media. ISO 14001 requires that 'significant aspects' be identified and evaluated. This method ensures that all aspects are identified though not evaluated. Note that this is a continuous improvement process and the Standard requires frequent review. Therefore aspects that are not significant now will become relatively more significant as the most significant aspects are improved. Therefore knowledge of all aspects is required. This structure provides this data. Fig 2.4 is an illustration of the above step being completed for one process.

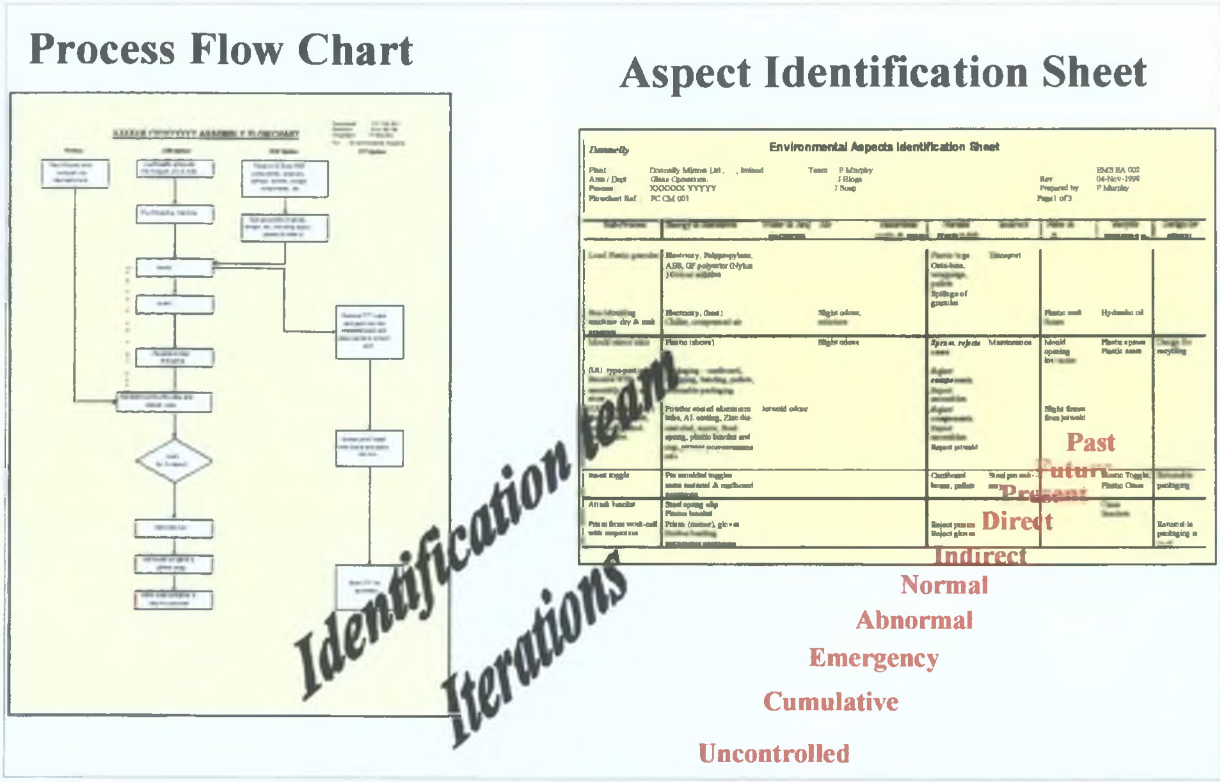

Fig. 2.4 The Documents for Identification of Aspects

2.2.3.4 Carrying out a Systematic Identification Exercise

In the case study the teams listed in Table 2.1 were assembled by the team leader with draft documents prepared in advance. Each was given its terms of reference and shown how to work through the process. First the flow chart/block diagram was completed and then the matrix. This was done for each process area/activity using the systematic method described in step 3. The exercise was carried out in a meeting room, was open and frank. Discussions and debates were useful sources of additional information and added to the depth of understanding for the team leaders. Fig 2.5 illustrates the progression of the process as twelve layers of aspect information was documented for the twelve active and passive activities.

2.2.3.5 Documenting the Identification Stage

The Standard specifies that '*The organisation shall establish and maintain (a) procedure(s) to identify the environmental aspects of its activities, products or services...*' This step is a necessary part of the aspects identification process that contributes to the requirement of establishing and maintaining procedures. As ISO 14001 is an accredited system it is necessary to provide documented evidence that the multi-dimensional requirements of the Standard were considered adequately. The documents produced for this stage will help to provide that evidence. In addition they will provide the basis for future reviews. The Standard does not specifically request a register of aspects but does specify that a procedure(s) be established and maintained. Therefore, a procedure to describe this process is required.

Both the procedure and the documents produced in the process should be controlled. To be controlled, documents are reviewed and approved by authorised personnel, are retained as a master by a controlling function, are issued as authorised copies to user locations, are revision managed to ensure that only current revisions are in circulation and a log of revisions is kept.

Having gone through the five steps described, the identification stage - bottom up and divergent - is completed. It is bottom up because it is data driven, focused on finding detail. It is divergent because it does not pre-judge the relative significance of aspects (i.e. zoom in) but instead zooms out to capture anything that might be relevant. The use of teams, made up of 'hands-on' experts on the 'elements of the organisation's activities, products or services that do, did or can affect the environment (aspect), provides the relevant data. The use of a systematic structured approach provides completeness of review. It is an iterative process, repeating steps (e.g. deriving indirect activities from direct activities and further indirect activities again) until cycles are exhausted. It provides documented data in a format that facilitates evaluation. It is a record of what is happening that can be referred to in future. It is a standardised method.

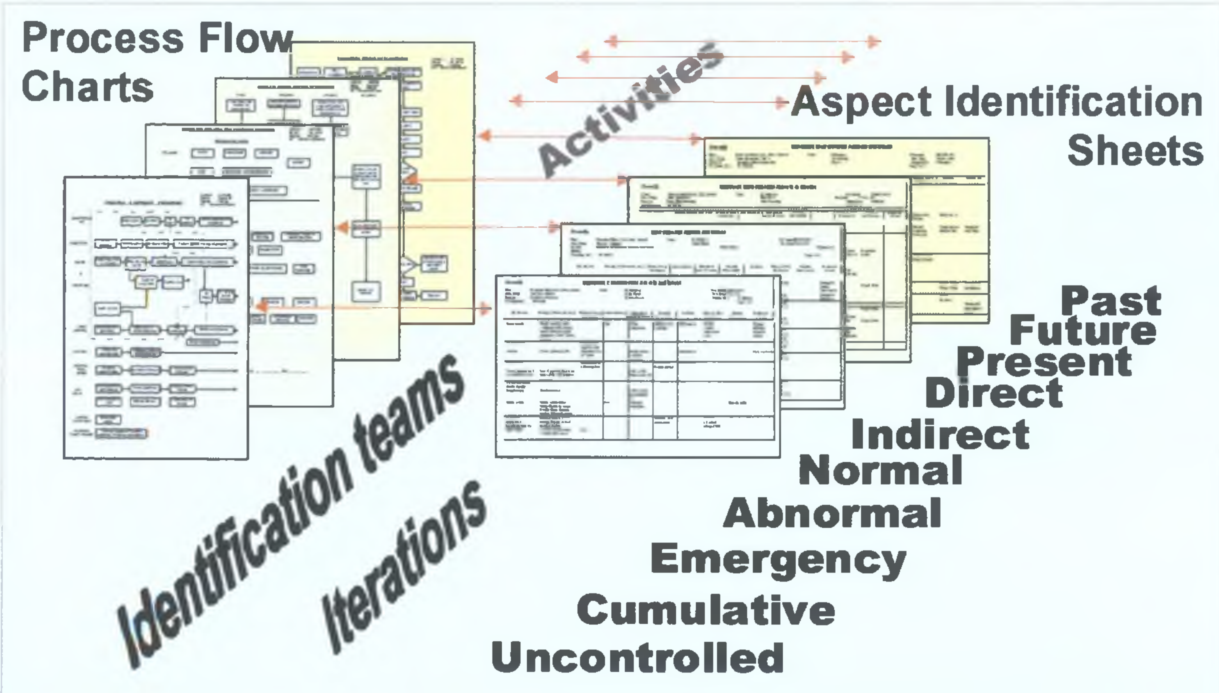

Fig. 2.5 Aspects Identification and Documentation Process – A Visual Overview

2.2.3.6 Advantages and Disadvantages of the Identification Approach

Advantages

- **Inclusive** - engages a good cross section of people and it covers the full spectrum of activities, media and dimensions

- **Systematic / structured** - there is a start and a finish and a method of covering all dimensions that newcomers can follow in a step-by-step format. It is easy to apply.

- **Provides continuity** - there is overlap between teams. If people drop out they can be replaced easily.

- **Forum for training and buy-in** – participants in this exercise get the opportunity to question areas they are operationally involved in from an environmental perspective. This exposure and early participation helps later EMS involvement and support.

- **Provides a well-documented base line** - useful for future review and for documenting change.

- **Uses readily available resources and tools** – tools are flow charting and spreadsheets e.g. Visio / Excel. Resources are in-house people.

- **Transferable** - i.e. it can be applied across different companies, etc.

- **It works** - it has been proven, having helped to achieve ISO 14001 first time in a complex organisation.

Disadvantages:

- **It ties up in house resources** - it ties up many man-hours of in-house people's time in the review process.

- **Heavy administrative workload** - to input and maintain the documents from the stage.

2.2.4 Step 3. – Evaluation of Aspects and Identification of Impacts

The evaluation stage is also systematic. Six steps were identified as follows:

1. Assemble the team to perform the evaluation, ensuring it is competent and representative.
2. Derive the list of site aspects to be evaluated.
3. Determine the risk analysis method to apply and document a systematic procedure.
4. Apply the procedure to the list of site aspects and rate the aspects/impacts using the FMEA.
5. Document the analysis for each aspect and associated impacts.
6. Rank the aspects in order of significance using the FMEA score for priority and to identify the significant aspects.

2.2.4.1 Assigning the evaluation team

In the case study, the team leaders that led the identification stage performed the evaluation because both team members were:

a) responsible for the company's IPC license and were therefore familiar with its technical and legal requirements including the Pollution Emission Register, waste and hazardous waste records, emissions to media, history of incidents and complaints, etc.;
b) formally trained as environmental auditors;
c) of professional chemical and engineering backgrounds;
d) jointly responsible for implementing the EMS in their respective roles;
e) jointly knowledgeable of all areas of the site's technical and operational activities;
f) empowered to draft in local expertise as required to comment on or explain local details.

Many organisations, which would not have any environmental license requirements would not have this type of technical expertise in the company, particularly small or medium sized companies (SME's). Fahey (1998) identified this area of technical expertise in the 1998 Irish survey. She commented that *'The initial Review, Register of Effects and Register of Legislation were the three areas companies had most difficulty with,* [while implementing an EMS] *thus necessitating the assistance of a consultant.'* If there is no in-house technical expertise, this stage of aspects identification / evaluation would be the appropriate stage to introduce the help of a consultant. In order to manage future costs and to ensure transparency of the process and outputs from the process, the introduction of a technical adviser at this stage should be to perform the dual function of technical advice and training of the team members.

2.2.4.2 Deriving the Site Aspects List

The output from this stage is a list of aspects to be evaluated. It involves determining a workable list of what are the elements of the organisation activities, products or services that can interact with the environment. This list is drafted from an environmental impact perspective as opposed to from an operational viewpoint. Table 2.2 shows the case study list.

It was conceptually difficult for the participants in the case study to determine how to differentiate between aspects. Some environmental aspects were associated with one process and some were associated with many. The challenge was how to logically arrive at an inclusive list of all aspects on site that would take all of the multi-dimensional requirements of the Standard on board. In the case study, the initial approach was biased towards an operations perspective. Because there were different and complex operations, each one with its own inputs, processes and outputs, the first attempt at aspects identification failed (i.e. was inadequate). This was largely due to complexities and overlaps. It was recognised that the list was a necessary output from the identification stage but how to arrive at it was conceptually difficult. There were two areas of difficulty. The first was ensuring that all of the dimensions given in the Standard would be met. The second was ensuring all aspects would be considered.

The challenge of how to consider everything was addressed by breaking up identification into two stages. The first stage was to review everything from an operations or process perspective. The site's activities were used to guide and lead the identification process. That stage has been described above. The follow on from that stage, which had provided an abundance of organised data, (i.e. data for each aspect, summarised in one of the nine columns of information on the spreadsheets) was to have a separate evaluation stage. In this follow on stage of evaluation, the real environmental aspects classes for the company would emerge. The best way to explain this is by way of an example.

2.2.4.3 Example from case study

Column 2 in all twelve matrices of the identification stage contains reference of all water inputs and aqueous outputs from the organisation. By looking down this column for all site activities/sub-processes with emissions it becomes apparent whether and where groundwater, surface water or sewer emissions merit examination in their own right. In the case study, where effluent is treated on-site and emitted to ground via a soak pit, emissions to groundwater was an obvious category of its own with its own unique issues. This was identified as an aspect in its own right for separate consideration and rating and ranking. Other secondary groundwater effects were noted in other areas, not associated with the treated effluent emissions *per se*. These were assessed under a different aspect heading, which included land and soil. Sewer and surface water emissions were separate categories to be looked at independently as domestic cleaning and toilet facilities (450 employees) go to sewer and the 9,000 sq. meter roof over the facility goes to a storm drain. Three classes of aqueous aspects were identified plus a fourth, combined with land. An examination of column 2 for all twelve activities/processes can lead an unfamiliar auditor or employee to where aqueous aspects apply in the site. This gives a transparent and consistent base line for future reviews.

A similar review took place for all of the nine other columns. Anything homogenous (i.e. can stand by itself and has its own operational drivers and measures) was given the opportunity for separate consideration as an aspect. For example, three separate aspects emerged for hazardous waste: one for solvents (from the class 12.2 IPC licence), one for other solvents, oils, etc. and one for a separate process hazardous waste that has the potential to increase with that particular product type. In this example, all three classes of hazardous waste have different independent life cycles and drivers in the process and have different prevention, minimisation and control parameters.

In addition to the aspects identified by examination of the columns of the identification stage, there were the guidelines from the Standard to consider. These acted as a checklist to ensure that all aspects for the site were included. Standard guidelines include aspects such as odour, particulate emissions, eco-system and visual impact in addition to obvious media emissions. Some of these guidelines, which specify what aspects should be considered, are shown in Fig. 2.1, earlier in this section (page 9). The list of classes of aspects should be inclusive of all site aspects and meet as a minimum, the guidelines in the Standard. The list is a compromise between all possible aspects on the one hand (a long list) and classes of aspects on the other hand (a short list). The list should be manageable. Twenty-two aspects were identified in the case study. These are given in Table 2.2

Aspect *(Area)*	**Aspect** *(heading for evaluation)*
Energy & resources	Energy Resource usage
Water use & aqueous discharges	Sewer emissions Effluent discharge Surface water emissions
Air emissions	Air emissions – solvents from silvering Air emissions – all other Odour Particulate
Hazardous materials and waste (solid & fluid)	Hazardous waste – solvents Hazardous waste – other Hazardous waste – EC cells
Normal waste (solid & fluid)	Glass and mirror cuttings Glass sludge (dig out & filter cake) Other non haz' waste including packaging
Indirect	Supply side and contractors
OHS	Environmental noise Occupational exposure (noise / chemicals / dust / radioactivity)
Land, nuisance, etc.	Eco-system Contaminated land Visual impact
Design	Product stewardship

Table 2.2 Case Study Aspects

2.2.4.4 Developing the Risk Analysis Method and Documents – The FMEA Approach

The case study is an automotive supplier accredited to QS 9001. This is an automotive Quality Management System (QMS) standard that the 'big three' USA car companies (Ford, Chrysler and GM) have developed based on ISO 9000 series standards. A Quality Management System (QMS) is a methodology for systematically addressing quality performance improvement. QS 9001 includes everything in ISO 9001 and some more. Each of the big three companies includes its own company specific requirements. For example GM has an electronic data interchange (EDI) specific requirement. The automotive add-on that is in the QS 9001 standard includes the use of Failure Modes and Effects Analysis (FMEA) for identifying quality risk. This method of risk assessment is well developed within the automotive industry. It is also a technique that has emerged as a popular method of environmental aspects and impacts evaluation. (Grimes, 1999).

ISO 14004 does not call for the application of any specific risk analysis technique. It gives basic guidelines, some of which can be recognised as part of the FMEA technique. Under step 4 of ISO 14004, 'Evaluate Significance of Impacts', the Standard says that evaluation can be facilitated by considering environmental concerns and business concerns. Under environmental concerns it lists:

- The scale of the impact;
- The severity of the impact;
- Probability of occurrence;
- Duration of impact.

Under business concerns it lists:

- Potential regulatory and legal exposure;

- Difficulty of changing the impact;
- Cost of changing the impact;
- Effect of change on other activities and processes;
- Concerns of interested parties;
- Effect on the public image of the company.

The Failure Mode and Effects Analysis (FMEA) technique is a Quality Management System tool. It is a controlled system for predicting what might go functionally wrong and it can be applied to a product or service (design FMEA) or the process that produced the product or service (process FMEA). It is both a philosophy and a systematic process. The philosophy is towards increasing the probability of detection, reducing the probability of occurrence and, ultimately designing the potential out. It is a systematic procedure in so far as it identifies potential failures, evaluates them, assigns a priority score, investigates root causes and assigns action to prevent them. An FMEA poses three questions to be answered:

- What might go wrong?
- What effects would result?
- What might cause it to go wrong?

Each of the impacts identified by the questions is rated and the factor of the values provides an index of risk called the 'Risk Priority Number'.

In the case study, a variant of the FMEA approach was adopted. This approach had due regard to the ISO 14004 requirements for environmental and business concerns given above. The document developed for aspects evaluation in the case study was constructed in sections as follows:

2.2.4.5 Section 1 of Evaluation Document: - Aspect Review

This was a description of the aspect bringing in relevant summary material from the earlier identification matrix. This description enables an employee or auditor to understand the scope of the aspect, how and where it applies on site and what developments are taking place in this area of activity. It comments where relevant on cumulative, past, future, abnormal, emergency and indirect dimensions of the aspect.

2.2.4.6 Section 2 of Evaluation Document - Associated Impacts

In this section the impacts, positive and negative, are discussed. Quantitative and qualitative comments are made to guide the reader through identified actual and potential impacts.

2.2.4.7 Section 3 of Evaluation Document - Risk Rating Factors F, L and S

The three categories of risk assignment used for risk assessment were:

- Frequency of occurrence (F);
- Likelihood of loss of control (L); and
- Severity of consequences (S).

Each factor was given equal weighting in the range from 10 (for worst case) to 1 (for best case). The value calculated for risk, called the Risk Priority Number (RPN) is a value between 1 and 1000 dependent on the values assigned to the three risk categories. The RPN value is the factor of F x L x S. Best case = 1 x 1 x 1 = 1 and worst case = 10 x 10 x 10 = 1000.

Bouchier *et al* (1998) cites the FMEA approach as being the most widely favoured aspects evaluation technique. The structure adopted in the case study was based on their model with some expansion. The rank value was given the range of 1 to 10 in the case study. *Bouchier et al* suggests 1 – 5 or 1 – 10. The higher range allows for more discrimination between aspects. While a useful guideline, Bouchier *et al*'s model required further refinement.

In particular, the S factor for severity of consequences was a challenge. After benchmarking other ISO registered sites it was decided to break it into sub-factors. Each of the sub-factors would be rated and scored independently using a score of 1 to five. Then, all five would be factored back to give an overall score of between 1 and 10 for severity. The five S sub-factors identified are listed as follows:

- Legislative and regulatory compliance.
- Potential community and employee sensitivity.
- Potential impact on air, land and water.
- Potential for resource depletion.
- Accidents and emergency.

Legislative and Regulatory Compliance

'By definition, legislation exists to control significant environmental aspects, otherwise the legislation would not come into being' (Whitelaw, 1997). *'Where the activities are subject to environmental regulations, such as effluent discharge licences, these are ipso facto deemed significant'* (Bouchier *et al*., 1998). Evaluation of aspects cannot be complete without the inclusion of consideration of compliance with legislative and regulatory requirements, past, present and future. Apart from the risk to the environment, non-compliance poses a risk to the business. ISO 14004 specifies *'Potential regulatory and legal exposure'* as a risk dimension of impacts to be considered under Business Concerns. A practical consideration of the inclusion of legal and regulatory consideration in aspects evaluation is that the company should have an up to date legal register and an understanding of its legal obligations including pending and future changes in the pipe line. While this *('a procedure to identify and have access to legal and other requirements*) is a requirement under section 4.3.2 of ISO 14001, this section of the standard (4.3.1) cannot be completed properly without it. A register of

legislation was available for the case-study aspects evaluation stage. One of the assessors had received prior training on the interpretation of the legislation. Decision rules for the scoring mechanism were reviewed for inclusion of this dimension in the case-study risk analysis.

Potential Community and Employee Sensitivity

'Notwithstanding any statutory nuisance considerations, the company is likely to regard its relationship with the local community as an important issue and a criterion against which significance is measured.' (Bouchier *et al*., 1998). The effect on the public image of the organisation is one of the Business Concerns listed for consideration by ISO 14004. Concerns of interested parties are also included in the recommendation. In the case study these considerations were taken into account in the severity part of the risk evaluation. Employee sensitivity was included both for business (i.e. costs of accidents, absence and insurance) and for community relation's reasons. Employees are an interested party, are a direct interface with the local community and provide informal public relations.

Potential impact on air, land and water

The third sub-category of severity of consequence evaluation selected in the case study was the potential impact on air, land and water. It is not possible to consider severity of consequences of the aspect on the environment without considering the direct impact on the main environmental media. This is the most obvious S factor.

Potential for resource depletion

ISO 14001, Annex A lists use of raw material and natural resources as one of the items to be considered in the review. The severity of consequences of the activity of an organisation would not be complete without some consideration of the impact of resource usage, particularly non-renewable resources. This sub-category was included in the case study evaluation of severity of consequences for that reason.

Accidents and Emergency

This sub-category was included to focus the evaluation on the question: what is the severity of consequences should there be an accident or emergency for the aspect under consideration? It was included in keeping with the Standard's requirement that the process to identify significant environmental aspects *'should consider ...the realistic potential significant impacts associated with reasonable foreseeable or emergency situations.'* (ISO 14001).

2.2.4.8 Severity sub-categories

The rational for the inclusion of the five sub-categories is given above. Some prior benchmarking had been carried out on other companies accredited to ISO 14001 who use the FMEA approach to see how they developed their risk categories and decision rules. Based on that material and interpretation of the Standard, consideration was given to the inclusion of other sub-categories. For example, under business concerns ISO 14004 suggests consideration of economic effects (*e.g. 'cost of changing the impact or effect of change on other activities and processes'* (ISO 14004)). This was considered and not included in the evaluation process. It was felt that economic effects are best left to the 'setting of objectives and targets' stage of the EMS and that economic decisions are a matter for the management of the organisation as a whole. Attempts at including the economic sub-category failed because robust decision rules could not be found. Even if found, the addition of this further factor would effect the overall ratings and the evaluators came to the conclusion this should best be dealt with elsewhere in the EMS. Having considered the Standard, guidance documents and benchmarks, it was decided to settle on the five sub-categories of 'severity of consequences' given above.

After agreeing the FMEA approach, using three equally weighted risk evaluation factors, one of which was broken into five sub-factors, the next stage was to review and agree the decision rules. The decision rules for the three risk factors, F, L and S are given below.

2.2.4.9 Decision Rules for Risk Assessment

<u>Frequency of Occurrence (F)</u>

How often does the aspect occur?

Score	1-2	Never, rarely, none, insignificant amounts, no impact.
	3-4	Low volumes, few incidents, small impact.
	5-6	Sometimes, under certain conditions.
	7-8	Frequently.
	9-10	Always, every time, high volumes, continuously.

<u>Likelihood of Control Loss (L)</u>

What are the chances of the aspect going out of control?

Score	1-2	Highly unlikely, excellent control in place, no control needed.
	3-4	Occasionally, 1% of time, partial control loss.
	5-6	Control loss up to 10% of time.
	7-8	Control loss up to 25% of time.
	9-10	Poor/no control where control is desirable, very frequently.

<u>Severity of Consequences (S)</u>

Severity of consequences of each aspect is denoted S. It is assessed for the following areas:

(i) Legislative and regulatory compliance.

(ii) Potential community / employee sensitivity.

(iii) Potential impact on air, land or water.

(iv) Potential for resource depletion.

(v) Accident and emergency situations.

A score for Severity of Consequences (S) is calculated from the following decision criteria:

(i) <u>Legislative and Regulatory Compliance</u>

Not regulated / no legislative requirement	= 1 points
Moderately regulated and compliant	= 2 points

Strictly regulated / legislated and compliant	= 3 points
Strictly regulated / legislated and occasionally non-compliant	= 4 points
Strictly regulated / legislated and consistently non-compliant	= 5 points

(ii) Potential Community / Employee Sensitivity

No observed reaction	= 1 point
Sporadic complaints	= 2 points
Widespread complaints	= 3 points
Vigorous community / employee action	= 4 points
Permanent injury or death caused	= 5 points

(iii) Potential Impact on Air, Land and Water

No measurable impact on environmental media	= 1 point
Local nuisance e.g. odour, dust / very low negative impact	= 2 points
Short term adverse impact on environmental media e.g. fish kill	= 3 points
Long term adverse impact on environmental media	= 4 points
Permanent damage to environmental medial or ecosystem e.g. Irrevocable damage to potable groundwater sources	= 5 points

(iv) Potential for Resource Depletion

No depletion of natural resources	= 1 point
Some depletion of **renewable** natural resources e.g. paper / water	= 2 points
Some depletion of **non-renewable** natural resources e.g. gas, oil	= 3 points
Large scale depletion of **renewable** natural resources	= 4 points
Large scale depletion of **non-renewable** natural resources	= 5 points

(v) Accident and Emergency situations

No risk / **trivial** risk (low probability and low environmental load)	= 1 point
Minor Risk (low probability and medium environmental load or medium probability and low environmental load)	= 2 points
Moderate risk (high probability and low environmental load or medium probability and medium environmental load or low probability and high environmental load)	= 3 points

Substantial risk (high probability and medium environmental load
or medium probability and high environmental load) = 4 points

Intolerable (high probability and high environmental load) = 5 points

The sum of the scores for each environmental aspect is the numerical value for the S factor. This represents the potential Severity of Consequences. It is factored back to give "severity" an equal weighting to frequency and loss of control. Scores assigned to each decision-making criterion take account of normal, abnormal and potential emergency situations.

Each environmental aspect is assigned an F, L and S factor as outlined above. The product of these values represents the Significance Rating (Risk Priority Number or RPN) for each environmental aspect. The higher the RPN value, the more significant the aspect.

2.2.5 Step 4 - Determination of Significant Aspects

2.2.5.1 Application of FMEA To Case Study

The identification flow charts and associated matrices was examined matrix by matrix and column by column to give the scope of each aspect and associated impacts. The respective aspects were described with reference to the multi-dimensional criteria of the Standard in the 'Aspect Review' part of the assessment sheet. This was done in a descriptive format with consideration of briefing future unfamiliar personnel. The impacts were described separately in the 'Associated Impacts' section. Next, the FMEA decision rules were applied, section by section. Each factor was rated using the decision rules and the rational was documented on the aspect review sheet. The rational included comments to guide how the score was given. An illustration of the document used for the risk assessment in the case study is given in Fig. 2.6.

Aspect Evaluation Sheet		
Aspect: **Aspect review** **Associated Impacts**		
Frequency: (F)	**Score**	
Likelihood of Loss of Control: (L)	**F** **L**	
Severity of Consequences (S) *Legislative and regulatory compliance.* *Legislation relevant to this activity* • •		
Potential community and Employee Sensitivity		
Potential impact on air, land and water *Potential for Resource Depletion* *Accidents and Emergency*		
Severity of consequences Factors (A +B+C+D+E)/2.5	**S**	
Risk Priority Number F x L x S = RPN	**RPN**	

Fig. 2.6 Aspect Evaluation Sheet

Using the above sheet and applying it as described next, all twenty-two aspects of the case study were reviewed, rated and documented.

2.2.5.2 Aspect Evaluation Process - Noise Example from Case Study

Having previously carried out a complete identification of all active and passive site activities, noise-associated issues are by now documented on the column matrices in the noise column. Next, the noise columns in the identification matrices are examined for potential noise issues. By evaluating the noise-associated items in the columns, the assessor can locate and describe the noise aspects and issues on site. The identification matrices provide a basis of information from a physical site and from an operations perspective. They provide high confidence that physical site issues are captured for evaluation. In order to have a complete evaluation other sources of information for the particular aspect should also be examined. In the case study this included the noise survey reports, the IPC license, a site map and the summary of noise in the Annual Environmental Report. The noise associated site issues were reviewed and documented in the Aspects Evaluation Sheet as shown in Fig. 2.7.

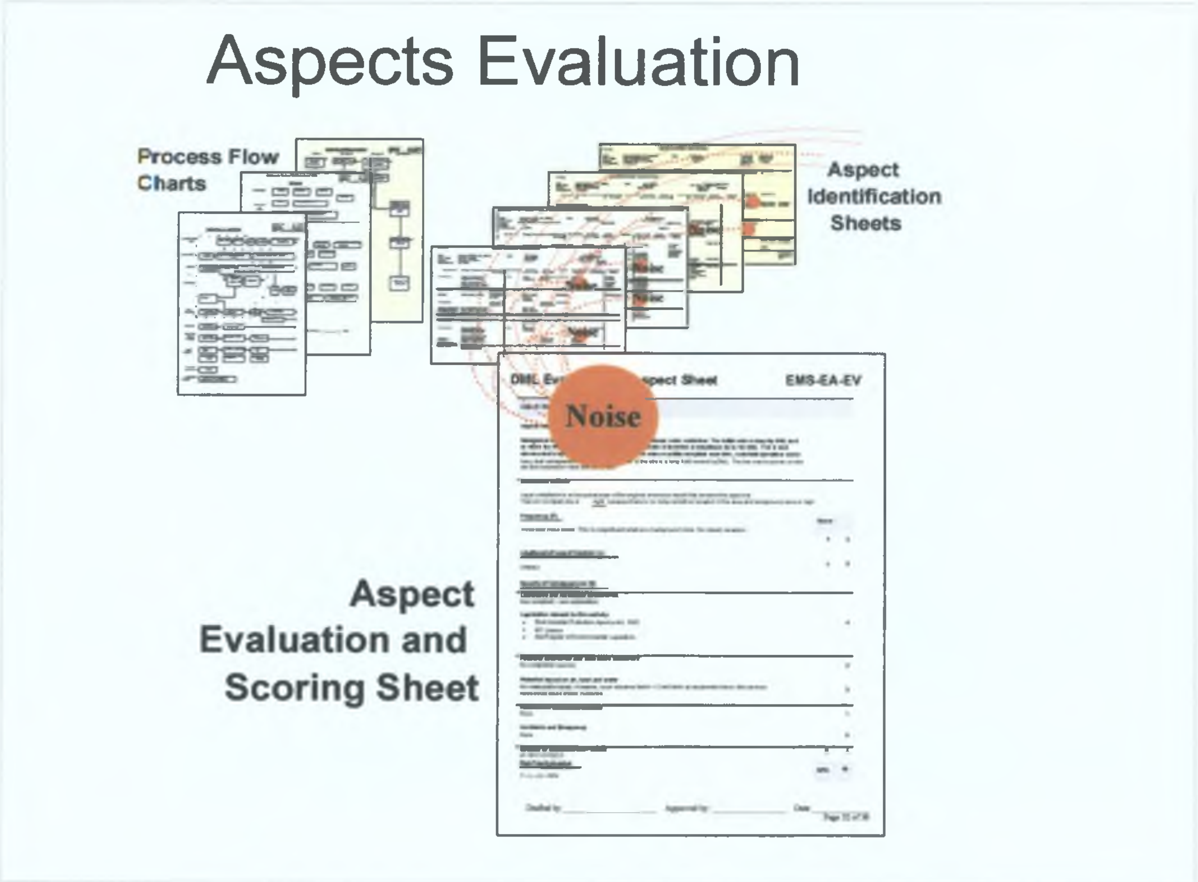

Fig. 2.7 An Illustration of the Mechanism of Assessment of the Noise Column in the Matrices showing Documentation of the Aspects Evaluation and Scoring Sheet for Noise

The completed sheet for noise is shown below in Fig. 2.8

Aspect: Environmental Noise		
Aspect review Background noise is as big a noise source in DML as process noise emissions. The initial noise survey by DML and on which the IPC license was based was erroneous. Noise is therefore a compliance issue for DML. This is well documented in reports and in the AER. There are no noise sensitive receptors near DML. Industrial operations and a busy dual carriageway bound the site. The rear of the site is a long field owned by DML. The two main sources on site are the compressor room and site traffic.		
Associated Impacts Legal compliance is an issue because of the original erroneous report that became the base line. There is no impact day or night because there is no noise sensitive receptor in the area and background noise is high.		
Frequency: (F) Three shift noise output. This is insignificant relative to background noise. No impact receptors.	**Score**	
	F	**2**
Likelihood of Loss of Control: (L) Unlikely	**L**	**2**
Severity of Consequences (S)		
Legislative and regulatory compliance. Non compliant – see explanation. ***Legislation relevant to this activity*** • Environmental Protection Agency Act, 1992 • IPC Licence • See Register of Environmental Legislation		4
Potential community and Employee Sensitivity No complaints received.		**2**
Potential impact on air, land and water No measurable impact. However, local nuisance factor = 2 and back up equipment noise / site services noise could cause a local nuisance.		**2**
Potential for Resource Depletion None.		**1**
Accidents and Emergency None.		**2**
Severity of consequences Factors (A +B+C+D+E)/2.5	**S**	**4**
Risk Priority Number F x L x S = RPN	**RPN**	**18**

Fig 2.8 Case Study Noise Evaluation

2.2.5.3 Aspect Scoring – Frequency

In scoring the noise aspect, a score of 2 was given for frequency. This was interpreted from the rule: score = 1 – 2 if '*never, rarely, none, insignificant amounts, no impact*'. In the case study site there is noise, it is insignificant relative to background noise and there are no sensitive receptors. That makes the quoted rule applicable. The rule allows a choice of 1 or 2. Because there is some noise, the higher value of 2 was chosen. The comment was recorded in the Aspect Evaluation Sheet.

2.2.5.4 Aspect Scoring - Likelihood of Loss of Control

The assessment was that it is extremely unlikely for noise on the site to be out of control. The rule that applies is 'highly unlikely, excellent control in place, no control needed' and it prescribes a score of 1 – 2. A score of 2 was assigned for highly unlikely, the higher score acknowledging unforeseen circumstances.

2.2.5.5 Aspect Scoring - Severity of Consequences

This factor was split into five as explained above. Each sub-factor was rated in turn. For legislative and regulatory compliance a score of 4 was assigned. This was in keeping with the decision rule 'strictly regulated / legislated and occasionally non-compliant'. Noise is a compliance issue for the case study. The IPC licence has noise emission limits. The base-line study at the IPC licence application stage was erroneous. Since then subsequent noise surveys have shown that noise is not an issue on the site nor are there any sensitive receptors. However, technically, as some noise surveys have noted noise levels in excess of the IPC licence, which was set against the base line, it remains a compliance issue. The above decision rule was therefore applied because noise is strictly regulated by the licence and some noise survey reports have reported levels above the licence limits. The higher score of 5 was not applied because there is evidence of some compliance. Similarly, the decision rules for the other four sub-factors were applied and scored. The final scores for the S factor for noise was

4, 2, 2, 1 and 2. These were totalled (11) and factored back to give a score 'out of ten' by dividing the total by 2.5. The score for S was 4.4.

The RPN for noise was calculated by multiplying the three factors for F, L and S ((2 x 2 x 4.4) = 17.6.) and the result was rounded to eighteen. This procedure was repeated for all twenty-two aspects.

2.2.5.6 Determination of Aspect Significance

The next stage in the process was the determination of significance. The guidelines given by Bouchier *et al* (1998) were followed. The twenty-two aspects were put into a spreadsheet along with the assigned scores. The aspects were sorted by score value and a bar chart of the aspects was plotted. By examination of the aspect's relative scores the significant aspects were identified as the highest scored aspects in order of score. This is illustrated in Fig 2.9.

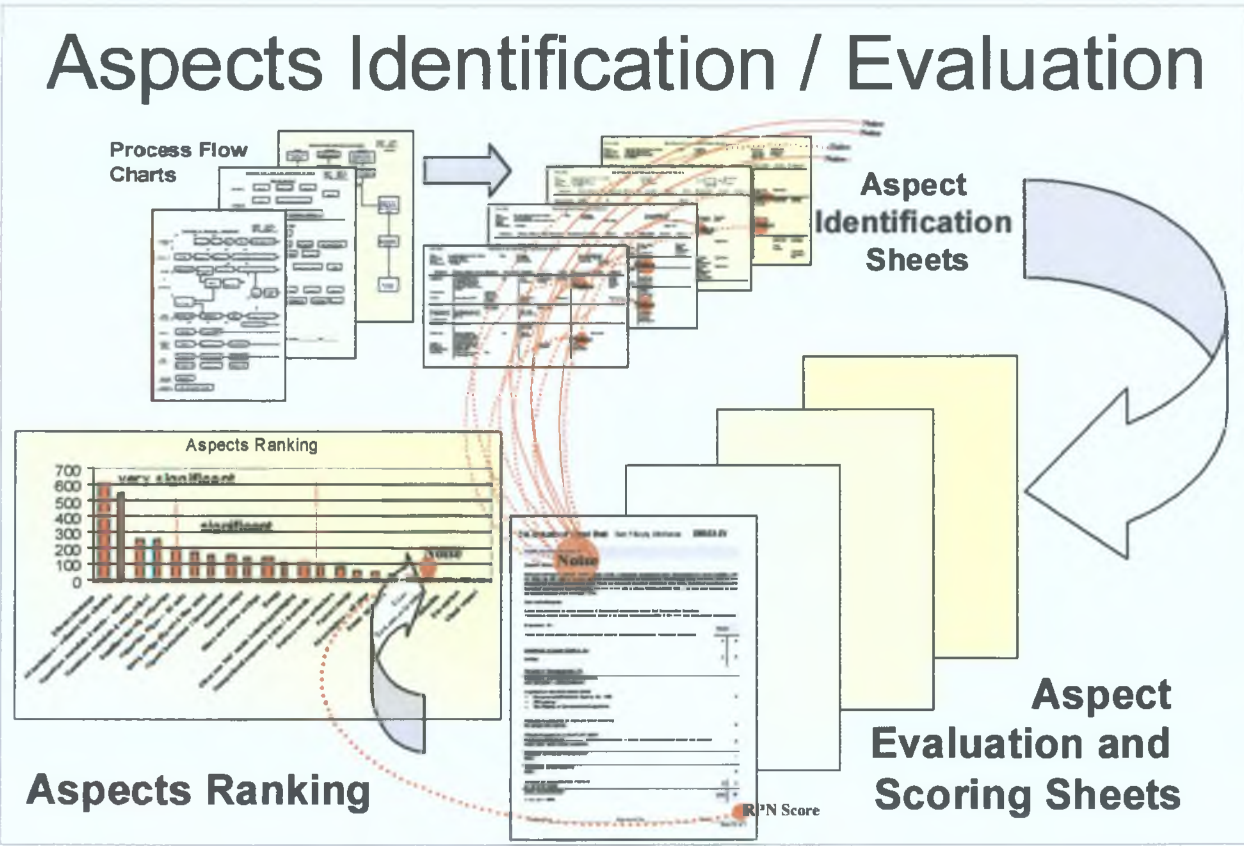

Fig. 2.9 Determination of Significant Aspects

The scores for each aspect were recorded on a spreadsheet and then displayed on a graph in order from highest to lowest. The spreadsheet is given in Appendix 2a and the graph is shown below. The most significant aspects are those with the highest scores. According to Bouchier *et al* (1998), who use an example of a hypothetical milk processor, significant aspects are determined by selecting an arbitrary cut-off value. Anything above that value is a significant aspect. Anything below it is not. Their cut off line of 20 points was selected from their FMEA scoring system (of 5 x 5 x 10 = 250) by applying judgement. In their example six aspects were selected as significant. It would appear from their example that the scores were looked at and judgements were made.

In the case study the graph was plotted and it was decided to let the graph speak for itself. By visual inspection there are two aspects considerably ahead of the rest (scores greater than 500). There are two more of similar score (between 200 and 300). These are ahead of a third group of eight aspects positioned between 100 and 200. The remaining aspects are below 100. In the case study, the graph of significance was plotted and judgement was applied. A slightly different approach was adopted than the approach described by Bouchier, *et al*. Anything above 100 was deemed significant while the four aspects above 200 were deemed very significant (in case study terms). This is shown in Fig. 2.10 below.

The selection of significant aspects from the ranked order is a somewhat arbitrary process as admitted by Bouchier *et al*. Where to draw the cut-off line is a matter of judgement. An important point in making that judgement is to consider the use that the list of 'selected aspects' will be put to. The list will become the basis for setting environmental objectives and targets. In the case study a more inclusive approach was adopted than the arbitrary method already described. Instead of looking at the exercise as a means to an end (the end being meeting the Standard's requirement to identify significant aspects), a more integrated approach was adopted for setting objectives and targets.

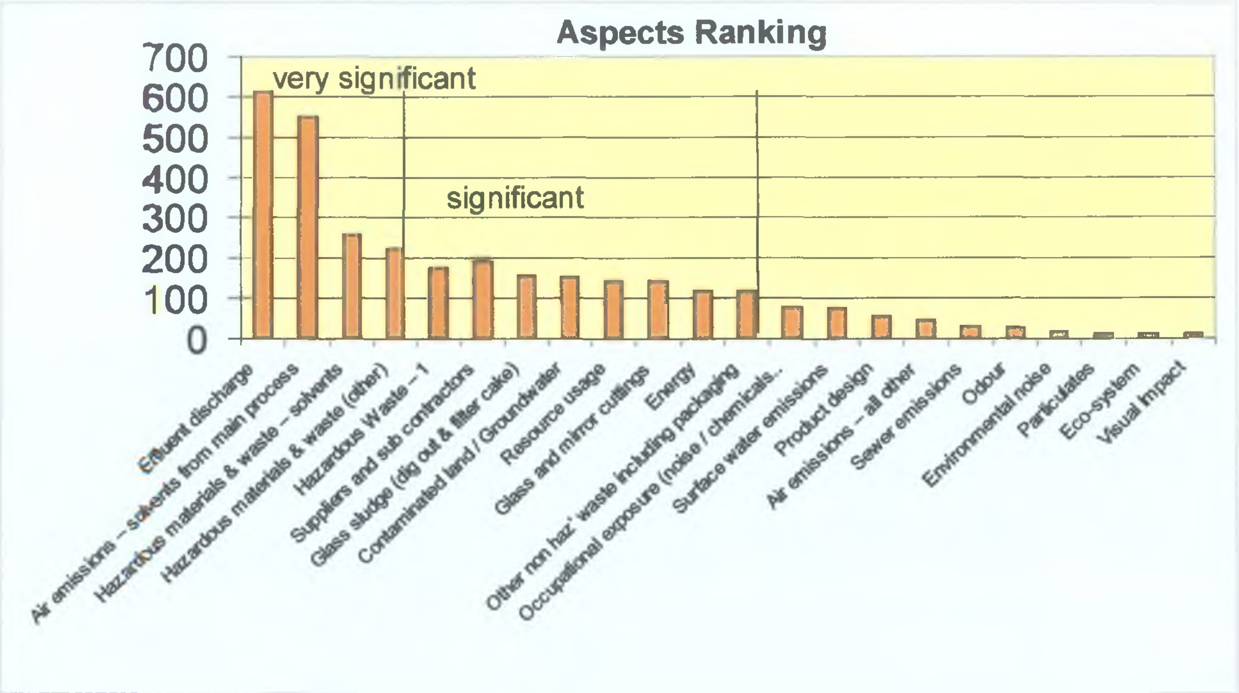

Fig. 2.10 Significant Aspects Determination – Graph of Ranked Aspects

2.2.6 Significant Aspects and Objectives and Targets

A two dimensional matrix was constructed showing the twenty-two aspects ranked in order on one axis and objectives and targets on the other. All aspects were included deliberately. Targets were set to address the most significant aspects. However, as was noted, an action programme to address one aspect could also affect another. In the intersection cells a 'tick' was inserted where an action target would improve an aspect. When the exercise was complete the matrix showed by the distribution of 'ticks' that it was significant aspects that were predominantly addressed by the targets. It also showed some minor aspects were being addressed to a degree. Through the use of this matrix it can be demonstrated by the case study company that objectives and targets are set to address significant aspects and in an integrated way – integrated with the company's operational realities. Integration not only includes meeting the Standard's requirements but also, meeting EPA requirements, supporting operational changes, dealing with product changes and being a part of the company's business. Some of these issues are looked at in the next section. A simplification of the matrix is shown in Appendix 3.

SECTION 3

DISCUSSION ON CASE STUDY

3.1 INTRODUCTION

In section two the aspects identification (and evaluation) stage of ISO14001 (section 4.3.1) was reviewed using a case study application. In this section the environmental aspects identification and evaluation process is discussed in a broader context using experiences from the case study to illustrate points. The discussion takes in consideration of environmental aspects from the operations management viewpoint. The case study is used for illustration.

3.2 CASE STUDY OBSERVATIONS

3.2.1 Case Study Priority Ranking

One of the first observations in the aspects identification and evaluation exercise of the case study was the high level of consistency between the ranking of significant aspects using intuitive ranking and by the application of the FMEA. Twenty-two categories of aspects were identified using the case study methodology. The standard requires that significant aspects be identified. Before the ranking exercise was commenced an intuitive reality check was carried out to see what the main or significant aspects might be. Because there was a focus on the company's IPC license, there was a high level of awareness of the company's products and processes that interact with the environment. Knowledge of the issues and where to find summary information quickly and easily (e.g. AER, PER, consultant reports) prompted and facilitated an easy attempt at guessing the order of priority. The AER and PER tables provide summaries of emissions magnitude. Intuitively it was considered that VOC emissions would be a significant aspect as the facility is a scheduled activity due to high VOC emissions. It is that aspect that brings the operation into the IPC license net. Intuitively it was also expected that effluent discharge would rate highly since that aspect is a continuous, high volume output from the main process, glass grinding. Other expectations were that hazardous materials aspects would rate highly due to toxicity and that the main process wastes (glass sludge from glass grinding) would be somewhere next in the order due to the volumes disposed of. On completion of the aspects identification and evaluation exercise it was found that the significant aspects ranking was largely consistent with those identified intuitively. Table 3.1 shows the relative rankings. The order of less significant aspects was not as consistently guessed. This is not considered important since the exercise is to identify significant aspects.

Aspect	FMEA Ranking	Intuitive ranking	Distance
Process effluent	1	2	-1
VOC process air emission	2	1	1
Hazardous materials - solvents	3	3	0
Other hazardous materials	4	4	0
Hazardous waste – type 1	5	8	-3
Suppliers and contractors	6	9	-3
Glass sludge	7	5	2
Land and aquifer	8	10	-2
Resource usage	9	11	-2
Glass and mirror	10	6	4
Energy	11	13	-2
Other waste and packaging	12	7	5
Occupational exposure	13	14	-1
Surface water	14	12	2
Design	15	15	0
Other air emissions	16	17	-1
Sewer emissions	17	18	-1
Odour	18	19	-1
Environmental noise	19	21	-2
Particulate	20	20	0
Eco-system	21	16	5
Visual impact	22	22	0

Table 3.1 Comparison of FMEA Ranking and Intuitive Ranking.

The comparison of ranking consistency was an important exercise in its own right. Nobody knows a site better than the people who operate it. In order to inspire confidence and acceptance of the results of the FMEA, variances should be minor and notable differences should be examined and explained, to satisfy any doubts. In the case study the four 'very significant' aspects (scores above 200) were guessed correctly, with a sequence variance of 1. The next group of aspects (scores 100 – 200) had differences of up to five places. But these were all within a narrow scores band. The two notable variances ('Glass and mirror waste' and 'other waste and packaging') were both over estimated (expected to have a higher ranking). The reason was found to be that the severity of consequences ratings (S factors) were higher for other aspects which had lower scales of magnitude by volume, pushing them up the order of significance and ahead of those high volume aspects. This demonstrated that subjectively, there was slightly more bias towards volume than severity of consequences. The FMEA corrected that.

3.2.2 Comparison of FMEA Factor Variations

The observation that the order of significant aspects as determined by the FMEA was close to an intuitive order prompted further assessment of the FMEA results. By applying different scores and factors to the decision rules, would the order and priority of rankings change? Would these changes be so considerable as to revise the selection of significant aspects? Variations were experimented with to see the effect on the ranking of the aspects. The purpose of the exercise was to identify and evaluate significant aspects using the same decision rules for assigning values, but using different factoring methods. A number of variants were tried and compared to the case study FMEA results. A summary of the findings is given as follows:

Variant 1: Use the nominal scores for S (5 for each sub-component) and do no factor S back to the same weight (i.e.10) as F and L. S now becomes 25 (i.e. five sub-components by five points each) and the max score becomes 2500.

Result No change in the significance. This is logical as everything was increased by the same factor.

Variant 2: This time use F and L as before but take out the legal, community, receptors and resource sub-factors from S. Use the risk sub-factor only for S and give it a weight of 10. The maximum score is 1000.

Result A marginal change but not of any significance. The same approximate ranking remains. The same significant aspects remain. Some of the mid range aspects have moved in priority and there is less discrimination (i.e. more aspects with the same scores).

Variant 3: This is similar to the original FMEA except that the risk sub component is given much higher weighting. It is given the same weight as the other four sub-components combined.

Result No significant change. A marginal movement at the fringes and marginal changes in the ranking between local aspects has taken place. One aspect has moved into the fringe of significance (aspect 5).

Variant 4: Multiply the severity (S) sub-components. This gives a weight of 5^5 to S (3125) and a possible maximum of 10 x 10 x 3125 = 312500.

Result Significant aspects categories remain largely unchanged. There are marginal changes in local aspect rankings and a higher variation than was observed with the other variations. One aspect has moved into the fringe of significance (aspect 5).

Variant 5: Factor the S sub components as in the case study. Instead of multiplying the three factors (F x L x S), add them (F + L + S) to get the FMEA score.

Result The orders remain mostly unchanged. There is far less discrimination between factors as the max score is 30 (10 + 10 + 10) as compared with 1000 when the three variables are multiplied.

The spreadsheet assessments for these reviews are given in Appendix three and are summarised in Table 3.2 below:

Variant No.	F	L	S	RPN	Comments
1	10	10	10	1000	Case study FMEA - multiplying F, L and S
2	10	10	25	2500	Using full S weighting – added
3	10	10	3125	312500	Using full S weighting – multiplied
4	10	10	10	1000	Revising S to rate risk only
5	10	10	10	30	Adding the variables F, L and S

Table 3.2 FMEA factoring variations applied to the case study

The conclusion from the exercise was that although the score changed, the relative order of significance did not change at all in many cases and changed so marginally in other cases as not to matter. In all cases the same significant aspects were determined. The result of the exercise suggests that the values that were found by applying the decision rules are more important than the factoring mechanism. The result also suggests that several approaches can be used, all of which will arrive at the same approximate rank order.

3.2.3 Information Sources and Aspect and Impact Quantification

An early consideration in the case study was the question of quantification of aspects. Apart from the points system used to quantify relative significance at the end of the exercise, the quantification of aspects' volumes and values was an issue throughout. Hunt and Johnson

(1995) make the following four points in reply to the question; "is quantification effects necessary in the evaluation process?"

- *It is wasteful of effort to seek detailed data if the effect is likely to be judged insignificant.*
- *Some quantification may be needed to reach that judgement.*
- *Quantification will in any event usually be required for setting objectives.*
- *Quantification is likely to prove increasingly necessary as performance improves, such that decisions on the relative significance of residual effects become less easy to make.*

As observed during the exercise, the answer to Hunt and Johnson's question is that it depends! On the one hand it makes sense that in order to assess an aspect one should have an accurate measure of its quantity in whatever the appropriate units are. On the other hand economic and practical considerations limit what information there is available, particularly for lesser aspects, and for what is feasible to assimilate at the aspects identification and evaluation stage.

In the case study the quantification issue was facilitated by the existence of data that had been compiled to support the IPC license. In particular, the summary information contained in the Annual Environmental Report was accessible and summarised in a useful format. Information was restricted to items that were reported for the license. This included summary data for air, water, waste, hazardous waste and noise. Aspects for those areas were relatively well supported with quantified information. The most significant aspects came from those well-quantified areas (e.g. VOC and effluent). Also, the next in line, i.e. hazardous materials and waste aspects, were well supported with quantified information. The lower priority aspects were not so well supported by quantified information (e.g. other air emissions (17) and sewer emissions (18)). Informed judgement was used to rate these aspects.

Cumulative effects were difficult to quantify. Summary data was not readily available. The practical way to get summary data for cumulative issues (e.g. handling gloves, aerosol cleaners, other consumables, etc.) is to run purchases exception reports (computer-sorted material summaries). It was found that this data was not readily available. Some cumulative effects data was available in the pollution emission register. Qualitatively, the matrices were very useful to find where the cumulative effects were but were not much of a support quantitatively. The existence of a supported IPC license was an advantage for the aspects identification and evaluation of the case study because it provided both internal expertise and summarised data. Both were of immense value for the identification and evaluation exercise.

Section two of this document discussed a method for identifying aspects, first from a process and activity perspective (in order to consider everything) and then, secondly from an environmental perspective. The documents developed by the methodology (flow charts and column matrices) provided a complete perspective on what was going on in the case study organisation. Those documents provided much useful information on what to find and where to find it. Although the flow charts and column matrices explored the full range of activities on the site (active and passive), they did not provide a complete qualitative overview. The flow charts and matrices, by themselves, were not enough to carry out the evaluation exercise. Apart from the 'quantification issue, discussed above, there was a lack of completeness in some important areas. This lack of completeness needed to be complemented and supported by documents from other areas. For example, environmental noise is an environmental aspect that was considered in the case study. While the column matrices were useful to determine sources of noise from direct and indirect sources they were not of themselves able to comment on noise levels at the boundaries nor did they identify background noise as an issue to consider. Other documents were necessary. An example is the noise survey reports that had been done for the company by third parties. Knowing what documents and sources of information to consult and where to find them is therefore an important issue for successfully carrying out the aspects identification and evaluation exercise.

The lack of readily available checklists was a notable point in the case study. Against that point it is worth noting some features of the forthcoming ISO 14015 standard. ISO/CD 14015.2 in its present draft shares the definitions of ISO 14001 for environmental aspect, environmental impact and an environmental management system. The draft standard clearly specifies that <u>it is not intended for use as a specification standard for certification or registration purposes or for the establishment of environmental management systems requirements.</u> It is intended instead as part of a broader business assessment process referred to as due diligence. Due diligence is the investigation leading to understanding the environmental issues associated with sites and activities and associated business consequences for potential site acquisitions. The standard is much broader in scope than section 4.3.1 of ISO 14001 (Environmental Aspects). Obviously, there is common ground for aspects identification and evaluation with regards to sources of information and impacts considerations. So while the standard does not directly apply to ISO 14001, it will provide useful checklists of documents and sources of information for aspects identification, examples of operational elements to observe during an investigation audit and a list of interviewees who could provide relevant information. The standard is, as yet, unpublished and was not available at the time of the case study application.

The case study intuitively addressed some of the complementary information source issues by the way it was organised. For example 'interviewees' were carefully selected as participants on the identification stage. By having the right cross-section of individuals involved from a functional perspective, it was easy to refer back to any of these individuals for clarification or for the benefit of their judgement during the evaluation stage. This was easy and informal.

3.2.4 A Continuous Improvement Dilemma from the Case Study

An interesting observation was made on the effluent aspect in the case study regarding the effects of one aspect on another. In this aspect mirror is ground to a wedge shape, using diamond wheels to machine the shape of the 'prismatic mirror'. The glass cuttings are removed as a solids suspension in water. The suspension is mainly glass fines, which is mostly silica. A small amount of cutting oil is used in the cutting process and this goes to the treatment plant. The twenty-year old treatment plant was not designed to remove oil to the tight concentration specified in the licence. The high hydraulic loading of the silvering process effluent, (which is oil-free) acts as a dilutant on the grinding process effluent with regards to oil concentration in the effluent. As the silvering process demand reduced by outsourcing mirror, the relative concentration of oil in the glass grinding effluent increased. Although there has not been any increase in the mass emission of cutting oil, the reduced dilution factor has resulted in the emission values exceeding the license concentration on occasion. The irony here is that continuous improvement in one area (VOC reduction) has resulted in license breach in another area (effluent discharge) without any deterioration (i.e. total mass emissions) in the area receiving the penalties. A further irony is that this has the effect of halting any water recycling improvements (further continuous improvement), as this would reduce the dilution factor further. This is an example of how the integration concept of the integrated pollution control system can apparently penalise the continuous improvement system of ISO 14001. It is expected to resolve this issue by seeking a change from concentration to mass in the forthcoming licence review.

3.2.5 Demonstrating the Aspects Identification Mechanism with an Example

The oils/fats/grease (OFG) emissions example brought out an interesting feature of the mechanism used for aspects identification. The reduction in VOC (a positive impact) in one process area has caused breaches of licence in a different process area (a negative impact).

This is the dilution issue discussed above. In the audit the auditor was interested to know how the OFG impact had been identified in the VOC aspect, as there was no oil associated with the VOC (silvering) process. This question was raised at the book audit and was documented for response during the site audit. The explanation is as follows.

The mechanism of the identification matrices is to distil out the different media, any associated indirect activity and design issues from each process or activity (under the nine column headings discussed in Section Two). The water related inflows, through-flows and outflows are listed under the water usage / discharge column for each process/activity. Therefore when evaluating the aspects at the higher level (i.e. effluent flow) across all processes and activities, OFG crops up in some effluent operations and prompts consideration of all others. This consideration at the effluent level prompts the silver line association with dilution. This is an iterative process that works across all processes individually first and then collectively. It is at the second stage that the connection between OFG and the silver line is made and documented in the cumulative context of effluent. This example helps to prove that the process works.

3.2.6 The Pre-audit

Another important lesson in the case study was the value of a pre-audit. The pre-audit exposed weaknesses in the aspects register that required further review and re-alignment. The main weakness was that while significant aspects were well identified, there was a piecemeal approach to the less significant aspects. Some parts of the aspect section of the Standard (Section 4.3.1) were not properly evaluated. For example some site services such as diesel tanks were not considered. This was missed because natural gas is normally used and diesel was used as a back up for the dual burner boilers. The tanks had been installed during the 1970's oil crisis. Consequent considerations such as buried diesel lines were also missed.

Exposure of the weaknesses of the aspect identification and evaluation forced a re-evaluation of the methods and this helped to develop the step-by-step inclusive approach. Without the pre-audit, the case study company would have failed the main assessment.

3.3 OPERATIONS MANAGEMENT AND ENVIRONMENTAL ASPECTS

3.3.1 Introduction

The management function in the organisation drives the organisation. It is responsible for making the strategic, tactical and operational level decisions. It is accountable for its decisions and is increasingly becoming subject to sanctions where environmental legislation is breached or ignored. Ignorance of the law is not a defence. For an environmental professional to assess organisation activities, products and services and fully understand the scope of the organisation there must be an appreciation of the management function that drives that organisation. Likewise, if a management team is really interested in an environmental management system it must come to terms with the environmental realities in its organisation and begin to integrate them into the strategic, tactical and operational level decision making. In the discussions so far on environmental aspects the focus was on mechanisms and decision rules. In the following discussion there is an attempt to bring out the operations management perspective on environmental aspects using case study examples.

3.3.2 Aspects and Legislation – the Time and Change Dimension

A dimension encountered in the case study was the time dimension specified in the standard, i.e. the inclusion of past and future environmental considerations. The review of this dimension brought out the realisation in the participants of how significant future considerations are in the overall context of the EMS and for the organisation as a whole. Two change drivers are significant. Those are operational changes, driven by the business, and environmental legislation changes, driven by the authorities. Both are integrated by ISO 14001 when the standard is cascaded down to suppliers. That is the case study situation.

The case study is an automotive supplier. Many automotive companies are cascading the requirement that in future all suppliers (to them) must have an accredited EMS. *"Last year the car giant General Motors announced that all its suppliers would be expected to meet the requirements of the environmental management standard ISO 14001 by 2002."* (Cottam, 2000). "*… organisations supplying the major automotive manufacturers – most notably Ford, Volvo and Rover – are actively encouraged, or required, to develop an EMS and gain certification to ISO 14001.*" (Carter and Wood, 2000) A condition required in order to be compliant with ISO 14001 is to be, and to remain, legally compliant with all environmental legislation. One must therefore be conscious not only of existing legislation but also of future legislation in the pipeline. The relationships are shown in Fig. 3.1.

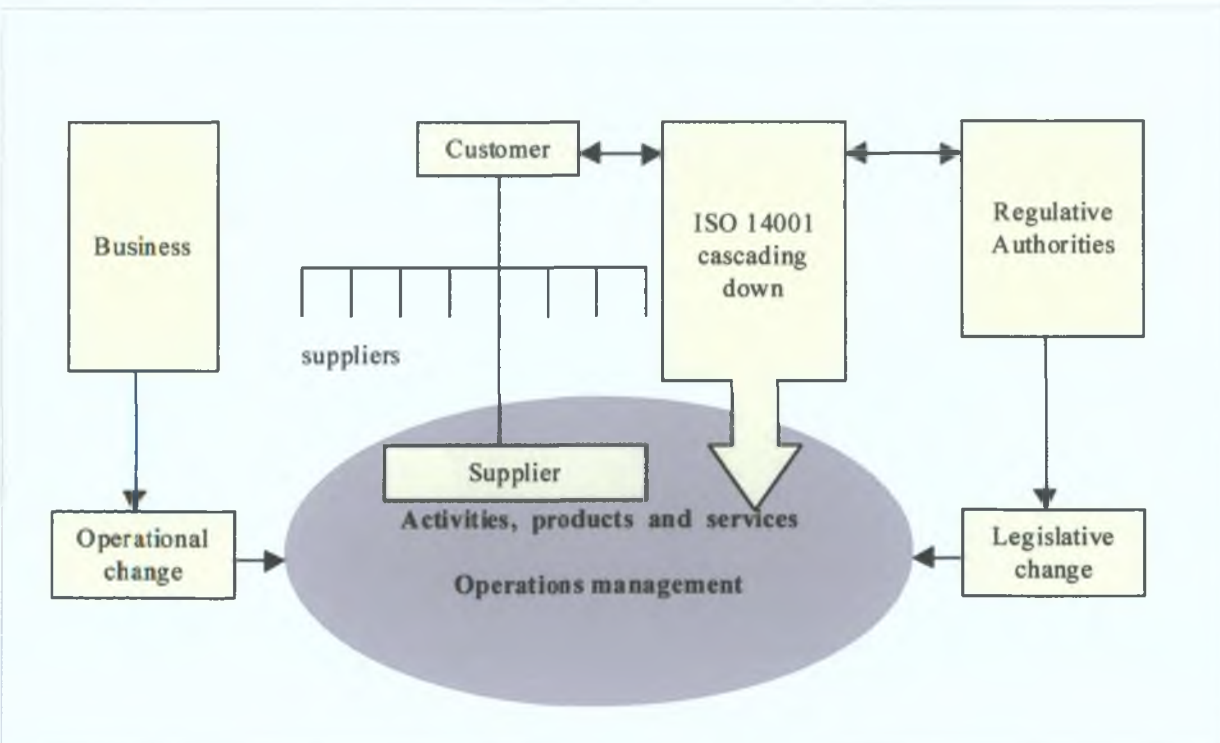

Fig 3.1 Aspects and Legislation - The Time and Change Dimension

3.3.3 Aspects and Legislation – Application to the Case Study

There is very significant legislation in draft form that is specific to the automotive industry. It is the 'End of Life Vehicle' directive (ELV). This directive will force the automotive industry to consider the environmental impact of disposal of vehicles at the end of their life. A similar directive is in the pipeline for the electrical components and electronics industry called the Waste Electrical and Electronics directive (WEEE). From an operations management perspective developments such as these are important, as they will force closer attention to environmental aspects in organisations in future. Operational change is constantly taking place due to business fluctuation, competition, new technology, product changes, consumer tastes, etc. These changes directly influence the aspects (activities, products and services) of the organisation. Therefore, operations managers will need to balance the conflicts of those two separately driven forces of change. Legislation exists in the first place to regulate environmental performance, and environmental performance is determined by how well the organisation operationally manages its aspects. This not static. It is dynamic.

3.3.4 Environmental Developments in Operations Management Theory and Practice

As a consequence of the developments discussed above, environmental considerations are being integrated into operations management theory and practice. Since 1985 changes have taken place to the manufacturing model. These are being driven by changes such as the integration of Japanese lean manufacturing, globalisation, new technology, harmonisation of trade regulations and others. Browne summarised the four characteristics of the evolving manufacturing model as follows: (Browne, Harhen and Shivnan, 1996).

- *Increased product variety,*
- *Reduced product life cycle,*
- *Changing cost structure,*
- *Increased environmental awareness.*

The contemporary organisation is becoming a far more dynamic area and this is reflected in the environmental aspects. A manufacturing theory, called 'concurrent engineering' (CE) is evolving a much broader spectrum that includes environmental considerations. Concurrent engineering was the integration of design for use with design for manufacturing. The new paradigm imposes a life cycle perspective onto CE and extends the design element in order to cater for environmental impact decisions at both the extraction and disposal ends. Roche (1998) illustrates the relationships of this new approach in Fig. 3.2 below.

Relationships between product life cycle and design Roche . [1998]

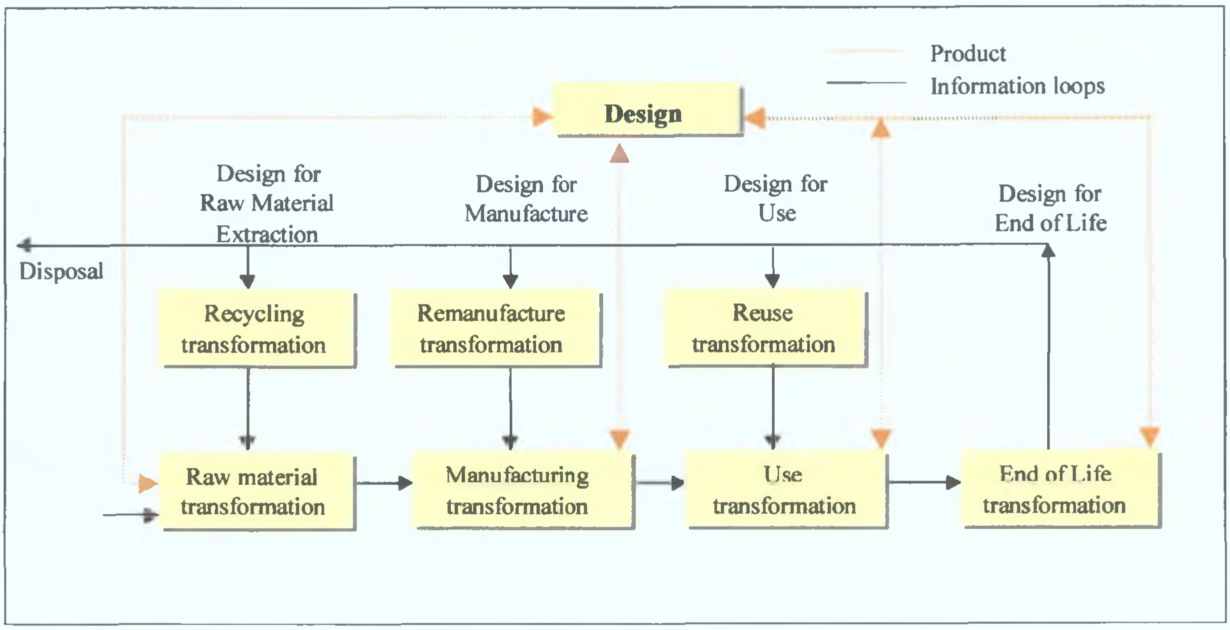

Fig. 3.2 Developments in Operations Management Theories

An observation from the case study is the increasing priority of indirect aspects with time. These include the supply side and design aspects. In the first aspect review of the case study (discussed in this document) the major aspects were direct. Since the case study, a second aspect review has taken place. The major aspects of 'effluent', 'VOC' and 'hazardous waste' are being addressed successfully by the EMP. It is becoming apparent that design and supply side aspects will become more significant in the future. This will happen as the top priorities are resolved (FMEA scores fall) and as legislation drives up the significance of design/supply side (FMEA scores rise). Both are related as design decisions influence out-source partnership decisions. It is not unreasonable to suppose that this is a universal trend. It is easier to address ones own direct aspects and these should be dealt with more quickly. Therefore it is suggested that indirect aspects will eventually emerge as the most significant aspects.

3.3.5 The Generic Value Chain and Environmental Aspects

Another way to consider the design / supplier partnership dimension of environmental aspects is through the Value Chain model (Porter, 1985). This has become a contemporary operations management concept. It extends the operations activities from inside the organisation to the external partnerships and relationships that affect the efficiency and performance of the whole business. It includes what goes on before (upstream) and after (downstream) the manufacturing or service activities of the site. It links inbound logistics (purchasing and delivery) through operations, outbound logistics (shipping), service functions and to the customer. It also links the organisation's infrastructure through people, technology, design and procurement. Like environmental aspects, this model of the organisation is multi dimensional. Just as the value chain shows operations managers how indirect activities affect the whole organisation performance the same can be shown about indirect aspects. The value chain is shown in Fig. 3.3.

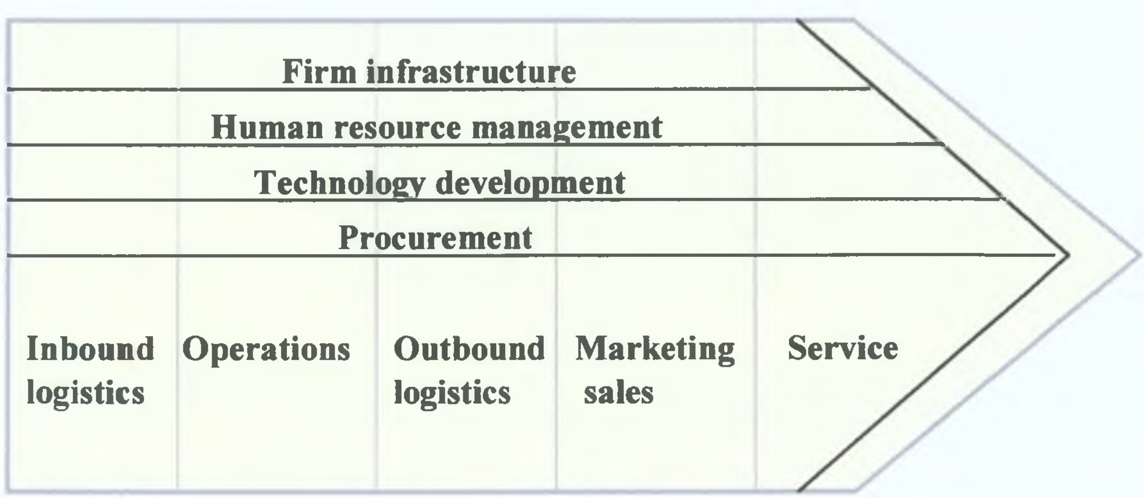

Fig 3.3 The Generic Value Chain

The recent management concepts (Brown *et al*, Roche and Porter) lend themselves to aspects identification and evaluation in so far as they highlight the importance of a holistic approach across a much broader spectrum than just activities inside the organisation. They help to demonstrate the relative importance of indirect aspects as aspects outside the organisation but which the organisation can influence through partnership.

3.3.6 Applying the Generic Value Chain Concept to the Case Study

Taking Porter's model, one of the significant aspect issues in the case study, arising from the VOC aspect, was the impact of outsourcing mirror. There are economic and environmental impacts associated with this aspect. The mirror process (silver line) in the case study is very old. It is a conveyor line where bought-in float glass is cleaned, silvered, coppered, primed and painted. The paint curing stages are responsible for direct and fugitive VOC emissions in the order of 50 tonnes per annum at full line production. At the time of the case study, emissions were reduced to less than half the levels at the IPC licence application stage. At that stage it had been decided to investigate the make/buy option and to look at supply partnerships. Retrofitting end-of-pipe abatement would be cost prohibitive and the purchase of a new process with integrated abatement systems was an economic decision that required full economic appraisal. Coatings alternatives were looked at such as water based paint. These were ruled out when trial results were reviewed. It was decided that the best economic and environmental option was to develop outsourcing partnership. From the value chain perspective this would extend the operation upstream into the supply chain. It could also affect the downstream performance of the product functionally and environmentally.

3.3.7 Indirect Aspects

Can an operation outsource its aspect and off-load its impacts to someone else? Looking upstream, from an environmental perspective, buying-in the mirror would move the VOC emissions aspect and associated impact away from the case study operation to the supplier. In so far as the in-house process is moved to a third party the aspect is changed from a direct to an indirect aspect. However, the decision 'where to place the order' has a direct bearing on the indirect impact. Therefore the aspect is still owned by the product/service user and only changes in status from direct to indirect. This is why the full consideration of indirect aspects is so important in the standard.

Consider the above example further. From an environmental perspective a regulated supplier who meets BATNEEC[1] would be preferable to one who is not regulated. But the decision is also an economic (cost, quality, delivery) and commercial (partnership and competitor relationships) decision. From an economic and commercial perspective an unregulated supplier in a low cost economy would have lower overheads and production costs with consequent lower prices. If economics is the only selection criteria, this could sway the decision towards the environmentally unregulated, lower cost supplier. That would have potentially higher negative environmental impact. The checks and balances from an environmental perspective that counter the economic bias are not very strong. If the aspects identification and evaluation is to be done honestly and with more than lip-service being paid to the environment, then vendor environmental performance should be considered and integrated into the vendor selection criteria. In the case study, the decision to buy in the largest component by weight of its product was a significant decision with significant economic and environmental knock on consequences. From this example it can be seen why operations managers should make an integrated decision on vendor selection that includes environmental selection criteria.

The previous example from the case study has a downstream application to the value chain. In so far as an outsourced product to be purchased from a new supplier is concerned, there may be environmental impacts from use and disposal perspectives. For example, in the case study, there is silver and copper on the mirror and lead in the paint that could leach into the environment. The third party product may have increased metals with increased negative environmental consequences of disposal. On the other hand it could have less metals with less environmental impact. The ISO 14001 definition of impact refers to any effect on the environment, whether positive or negative. In the case study, outsourcing has reduced lead and eliminated copper (i.e. a positive impact). So, even if the aspect is moved to a third party by buying in, the aspect will still be an issue for the company. The significance of the aspect, using the risk scoring mechanism (FMEA) may change, as a result of positive or negative effects on the environment relative to other aspects.

The evolution of aspects discussed earlier and the value chain concept above have a practical dimension for aspects identification and evaluation in general. Taking the view that aspects are identified and evaluated as families, once progress is achieved on significant aspects the less significant families become more significant (discussed above). In the case of supply side activities consideration should be given to breaking that aspect down further once it becomes more significant. The reason for this is so that objectives and targets to be set in the EMP against significant aspects can be more meaningful. Supply side can be exploded using operations management principles as shown in Fig. 3.4

The value chain of suppliers of products and services can be considered as a spectrum of suppliers. On one side are those who have strategic interests in doing business with you and general suppliers with no partnership interests in you on the other. It is those strategic relationships where the purchaser has more influence that have most scope for laying down environmental conditions. Examples are, specifying materials, processes or systems, such as ISO 14001. Within the strategic partnership relationships, those which are more environmentally significant are the obvious places to focus first (P-S). For example, waste contractors, major materials suppliers, etc. The non-strategic suppliers are most difficult to influence because your business is so relatively unimportant. The environmental impact

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[1] BATNEEC means Best Available Technology Not Entailing Excessive Cost

against the difficulties of influencing control can be shown as a four-quadrant priority matrix. Quadrants 1 and 3 are where most significant environmental effects can be found. 1 and 2 are where most influence lies.

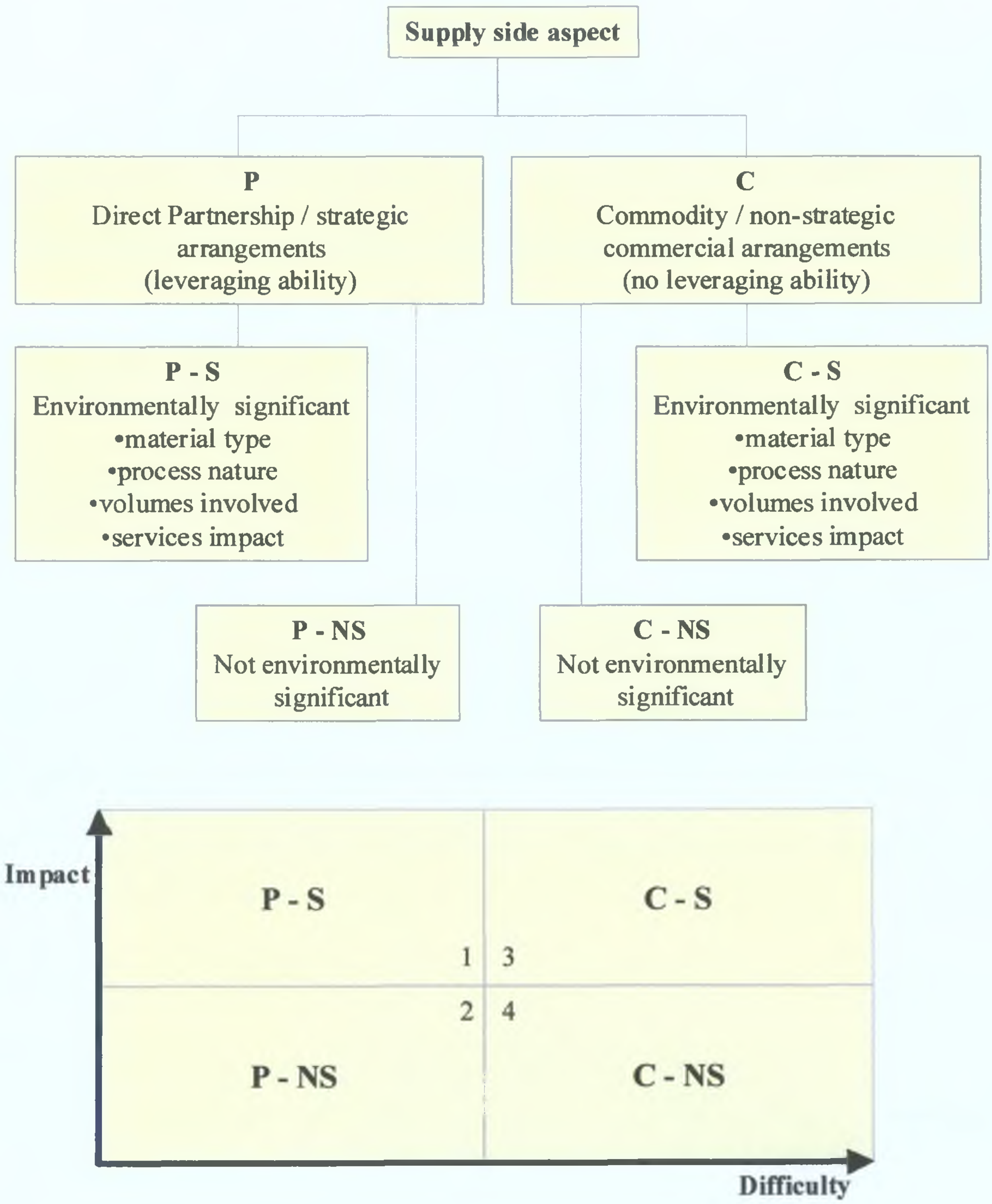

Fig. 3.4 Operations Management Involvement in Aspects Identification and Evaluation

3.3.8 Environmental Aspects and Operations Management Involvement

There are strong economic arguments for operations managers to be actively involved in the aspects identification and evaluation process of their own site and on an ongoing basis. The exercise not only provides the base line for continuous improvement; it also affords the opportunity to gain an integrated understanding of the operation's environmental economics. The balanced scorecard approach (Kaplan, 1996) is a formal recognition of the need to develop and integrate qualitative as well as quantitative metrics[2] to aid day-to-day operations management decision making. These metrics should incorporate all of the key measurables that are important for the business. If environmental impact is to be important criteria to support the continuous improvement requirement of ISO 14001, then suitable metrics should be developed and attached to the main aspects. Under ISO 14001 this is done through the objectives and targets. Under the balanced scorecard approach compartmentalised targets and measures are not allowed (i.e. financial, quality, environmental, etc.) in favour of one integrated set of 'in your face' metrics. But apart from the above holistic argument there are other reasons why an operations manager should want to get down to the nuts and bolts of understanding his/her environmental aspects.

In the case study example of environmental noise it was noted that the environmental impact of environmental noise from the site is negligible. There are no sensitive receptors in the area and the levels of background noise coming into the site from the dual carriageway is more significant than any noise leaving the site. Technically there is no environmental impact from this aspect. However, since the base line measurement on which the EPA set its limit values was erroneous (i.e. lower than combined site and background noise), technically the case study site may be in breach of its licence from time to time. If a customer chooses to use license breaches as a metric for vendor assessment and for vendor comparison then the case study company could lose future orders. Noting the direction that the automotive industry is going, (i.e. suppliers to be ISO 14001 registered) such a metric is very possible. In this case,

[2] A metric is Management Accounting jargon for a measure. It can be a ratio or some 'made up' measure to suit

with no environmental impact, the case study company could be compared unfairly against a competitor who does not have better environmental performance. In a future world where environmental performance metrics become a criterion for selection, operations managers will need to understand the environmental aspects of their organisation in the overall business context. The aspects identification and evaluation exercise for ones own site is a good place to start learning.

3.3.9 A Product Life Cycle Dimension to Environmental Aspects

There is another operations management area called product life cycle (Evans, 1993). The theory describes how product life cycle has reduced as the speed of introduction of new products has increased. All products go through design, development, introduction, growth, maturity and decline stages during their life. Fig. 3.5 shows the generic product life cycle.

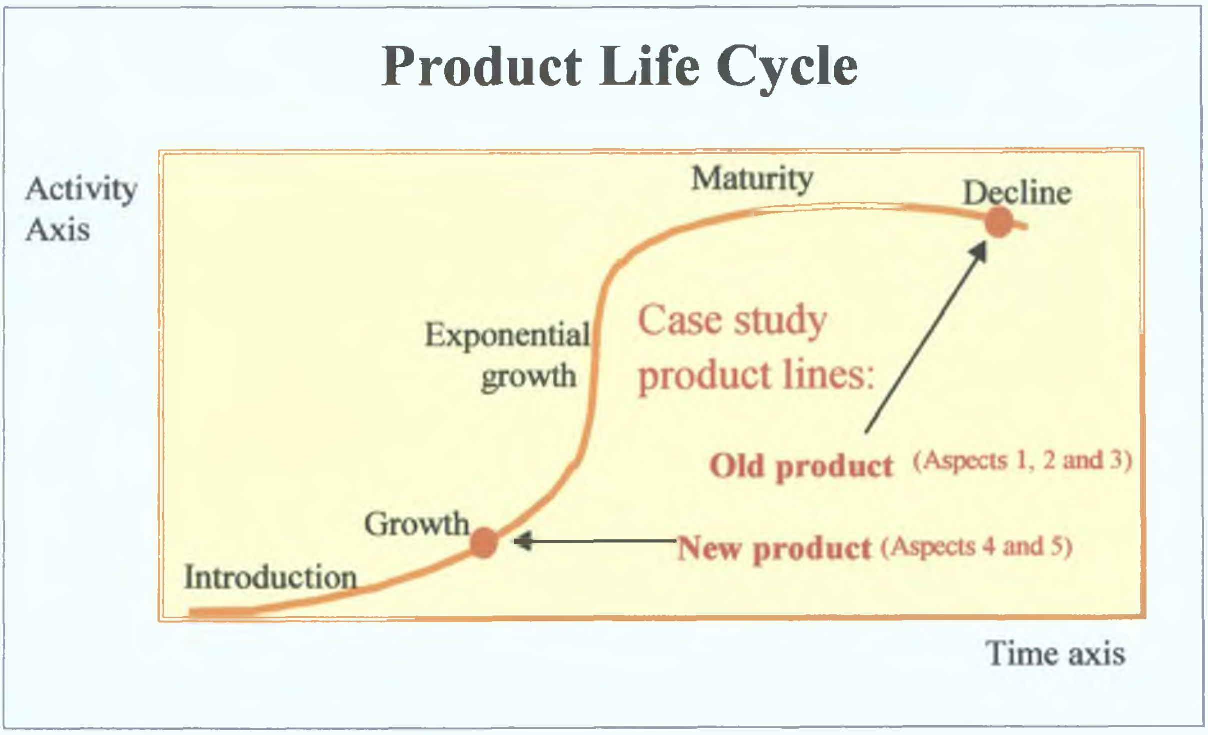

Fig. 3.5 Generic Product Life Cycle Curve

In the case study where automotive mirror is the core business, new technology has enabled the development of an automatic dimming mirror. Instead of having to operate a mechanical

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the circumstances. The term is now common in third level courses on Management.

lever to change the day reflection to night and vice versa the new mirror uses electronic sensors to change the reflectivity of the mirror automatically. The production line for the mechanical mirror is thirty years old. The product is 'mature' and heading into decline as the electronic mirror begins to take hold in the market. The mechanical mirror is responsible for the most significant aspect in the case study, the effluent from the treatment plant. For this aspect it is not economically feasible to invest in expensive, 'clean technology' or abatement equipment because the economies of scale (sales volume) and depreciation life (reduced life of the product) do not allow, owing to the maturity of the product. The opposite holds true for the other product, which is responsible for aspects four and five in order of priority. These are points to take into account when setting objectives and targets.

3.4 CONCLUSION

In the previous section the mechanics of aspects identification and evaluation was discussed. In this section the issues surrounding environmental aspects identification and evaluation were discussed. The discussion took in the broader operations management context. Some practical considerations were brought out with examples from the case study. These are summarised in Section Five along with some additional observations from the other two applications.

There are strong economic arguments for operations managers to be actively involved in the aspects identification and evaluation process of their own site and on an ongoing basis. The exercise not only provides the base line for continuous improvement; it also affords the opportunity to gain an integrated understanding of the operation's environmental economics. The balanced scorecard approach (Kaplan, 1996) is a formal recognition of the need to develop and integrate qualitative as well as quantitative metrics[2] to aid day-to-day operations management decision making. These metrics should incorporate all of the key measurables that are important for the business. If environmental impact is to be important criteria to support the continuous improvement requirement of ISO 14001, then suitable metrics should be developed and attached to the main aspects. Under ISO 14001 this is done through the objectives and targets. Under the balanced scorecard approach compartmentalised targets and measures are not allowed (i.e. financial, quality, environmental, etc.) in favour of one integrated set of 'in your face' metrics. But apart from the above holistic argument there are other reasons why an operations manager should want to get down to the nuts and bolts of understanding his/her environmental aspects.

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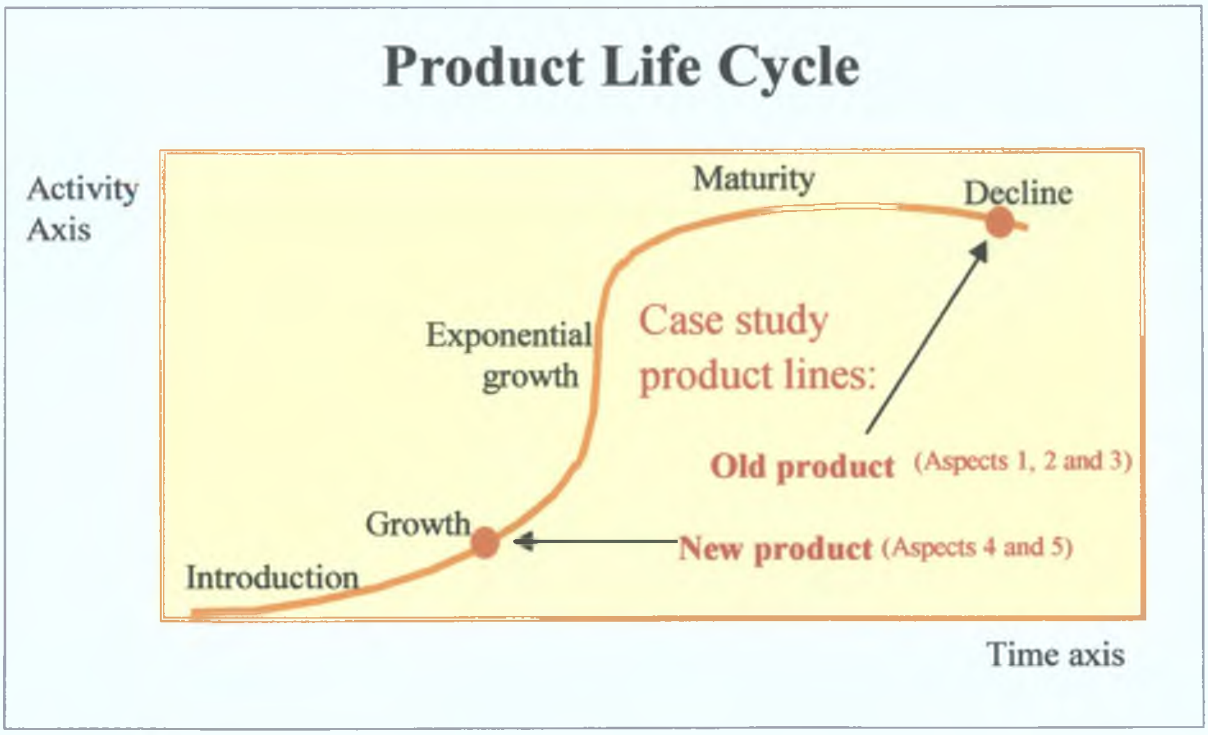

Fig. 3.5 Generic Product Life Cycle Curve

In the case study where automotive mirror is the core business, new technology has enabled the development of an automatic dimming mirror. Instead of having to operate a mechanical

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the circumstances. The term is now common in third level courses on Management.

lever to change the day reflection to night and vice versa the new mirror uses electronic sensors to change the reflectivity of the mirror automatically. The production line for the mechanical mirror is thirty years old. The product is 'mature' and heading into decline as the electronic mirror begins to take hold in the market. The mechanical mirror is responsible for the most significant aspect in the case study, the effluent from the treatment plant. For this aspect it is not economically feasible to invest in expensive, 'clean technology' or abatement equipment because the economies of scale (sales volume) and depreciation life (reduced life of the product) do not allow, owing to the maturity of the product. The opposite holds true for the other product, which is responsible for aspects four and five in order of priority. These are points to take into account when setting objectives and targets.

3.4 CONCLUSION

In the previous section the mechanics of aspects identification and evaluation was discussed. In this section the issues surrounding environmental aspects identification and evaluation were discussed. The discussion took in the broader operations management context. Some practical considerations were brought out with examples from the case study. These are summarised in Section Five along with some additional observations from the other two applications.

SECTION 4

APPLICATION OF THE ASPECTS IDENTIFICATION AND EVALUATION METHODOLOGY TO OTHER COMPANIES

4.1 INTRODUCTION

In this section a brief description is given of two further cases where the identification and evaluation mechanism that was used in the case study was also applied. The two additional applications were done in order to prove that the mechanism works and can readily be repeated in a different operation. These applications provided the opportunity to learn more about aspects identification and evaluation and to appraise the mechanism.

Overall, it was learned that the system discussed in the case study works well. The two further applications gave some additional points to consider. These are discussed here and some comparisons are made.

4.1.1 Introduction to Company 1

The first application was by a third party company that has no business relationship with the original case study company. This company, Thermo King Europe Ltd., (called company 1 in this text) is a leading manufacturer of transport refrigeration units. It is based in Galway and manufactures a range of transport refrigeration units for trailers and trucks. Its main manufacturing activity includes metal fabrication, finishing and general assembly. There are about 750 people employed there. The site is subject to a Class 12.2 Integrated Pollution Control Licence. It is part of a large global organisation.

4.1.2 Introduction to Company 2

The second application was to a sister company engaged in manufacturing exterior and interior automotive mirrors. This company, like the case study, supplies the automotive industry and is subject to the same demands as the case study. Its main manufacturing activity is moulding and assembly of automotive mirrors. The company, called Donnelly Vision Systems Ltd., is based in Manorhamilton, Co. Leitrim. There are about 140 people employed there. The site is not a scheduled activity under the Environmental Protection Agency Act, 1992 and does not require an Integrated Pollution Control Licence.

4.2 CASE STUDY AND OTHER COMPANIES – A COMPARISON

4.2.1 Comparison of Descriptions of Case Study and Other Companies

The three activities (case study and the other two companies) are summarised in Table 4.1.

	Case Study	Company 1	Company 2
Operation / activity	Manufacturing	Manufacturing	Manufacturing
Product Type	OEM[1] /Tier 1	Tier 1/ Tier 2	Tier 1 / Tier 2
Market	Automotive components	Transport Refrigeration	Automotive components
Location	Midlands	West	North West
Employees	~450	~750	~140
IPC Licence	Class 12.2	Class 12.2	Not scheduled
Number of Aspects defined	22	21	14
ISO 14001 auditor	SGS Yarsley	NSAI	SGS Yarsley

Table 4.1 Summary of Case Study and Companies 1 and 2

ISO 14001 can be applied to service as well as to manufacturing activities. The three cases reviewed are all manufacturing plants. Organisational form is not an accident. *"The nature of the product or service portfolio that an organisation is engaged in manufacturing or delivering is the primary determinant of corporate form."* (Evans, 1993). All operations exist somewhere on the spectrum shown in Fig. 4.1. The five groups represent the five classic manufacturing categories. The activity spectrum is described in terms of production volume

[1] OEM is Original Equipment Manufacturer. A tier 1 supplier supplies functional parts and systems to an OEM. A tier 2 supplier supplies to a tier 1 manufacturer.

(from batch size of one to batch size of infinity) and variety (range of features). The spectrum extends from project type operations (e.g. large civil engineering projects such as bridge building) to continuous flow operations (e.g. gas production and distribution lines). The three cases are all located at mid range of the spectrum. All three are batch manufacturers.

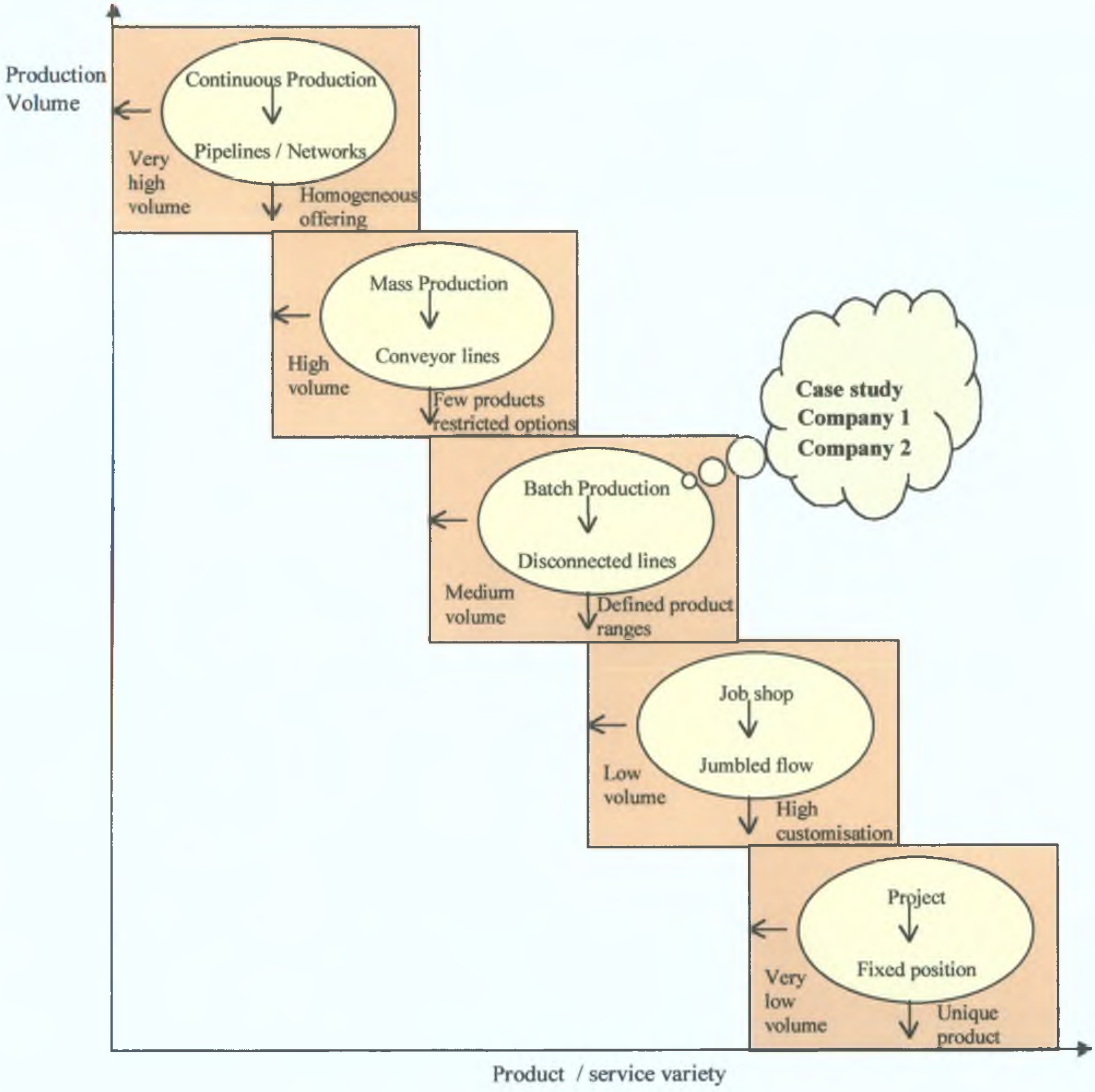

Fig. 4.1 Operations Classification – Case Study and other two Applications

4.2.2 Aspects Identification and Evaluation in Company 1

Company 1 had already done some work preparing for ISO 14001 when it was given the model for aspects identification and evaluation. It was not successful at its first audit and aspects identification and evaluation was one of the main areas of weakness identified. It decided to look outside the organisation after the audit and it was at that point that it adopted the model used in the case study. The model was applied over the three-month interval to the re-audit.

Company 1 has an IPC licence. It manufacturers transport refrigeration units. It is an original equipment supplier (OEM) with some tier 1 dimensions. It is different to the case study in so far as there is a much narrower range of product possibilities. A transport refrigeration unit has far more components than an automotive mirror but there are far more types of mirror than transport refrigeration units. Therefore there were far less product / process variables than in the case study. This meant that there was not a need to operate the flow chart / identification matrix in the same way as in the case study. The information was mostly available already for two reasons. Firstly, each product / process had up to date flow charts. Unlike the case study, these were generic (i.e. covered the full process spectrum). The identification teams used these charts, bills of material (BOM's) and work instructions to check out what materials were used in each process. Secondly, the company already had a significant amount of aspect information gathered from its first preparation for ISO 14001. For expediency, a gap analysis, using the case study material as a guide was an effective way of identifying any inadequacy. This was the method used.

4.2.3 Method of Transfer of Methodology – Company 1

The method / steps used to communicate the methodology to company 1 and elicit the results of its application was as follows:

- Company 1 was approached informally through the environmental support function and was asked if it would consider using the proposed methodology. This was a two way process as company 1 was already looking outwards to benchmark ISO 14001 companies. Contact had been made through the 'Engineering Industries Association' (EIA) of the Irish Business and Employers Confederation (IBEC), which company 1 had hosted and the case study company had attended.
- The case study supplied an electronic file of the methodology, including documents. These were reviewed and explained.
- Company 1 agreed to adopt the methodology and amended it as appropriate.
- Company 1 completed the aspects identification and evaluation exercise using the amended methodology and was audited successfully.
- After the audit the aspects file was reviewed using email and during a half-day review, presented by the facilities environmental engineer.
- The aspects file was made available for comparison but not publication. Aspects identification and evaluation measures were supplied as requested.

4.2.4 Comparison of Company 1 Results with Case Study

The FMEA method of aspects evaluation that was used in the case study was closely followed in company 1. The same decision rules and factoring were applied. The same method of documentation was used. The results were displayed in the same table format. Each aspect was well documented. It was therefore easy to make comparisons between aspects from the case study and company 1.

The number of aspects identified for evaluation was very similar to the case study. There was one more than in the case study. Of note was the close similarity between the most significant and least significant aspects, from aspects category and score perspectives.

Being a class 12.2 licensed company, VOC emissions are high, so this aspect is classed as significant. Hazardous materials and hazardous waste was broken into four different classes as in the case study. Each of these classes has their own drivers.

Many of the aspect classes, though similar, were treated differently. For example, unlike the case study, normal waste was split three ways between supplier packaging, shipped packaging and normal waste. In the case study returnable packaging is proportionally very high so the waste and packaging aspect (combined packaging and normal waste aspect) was not very significant. However, as discussed in the previous section, the splitting of that aspect will be appropriate in future when the aspect becomes relatively more significant.

There was a different approach to supply side activities. This was split between sub-contractor and general supply activities. The organisation can have relatively more control over sub-contractors than it can over general suppliers. This sub-contractor / supplier distinction is therefore useful.

In general the table of scores for the FMEA bore a strong resemblance to the case study although some aspects were treated differently as discussed above. This can be put down to the fact that the processes and process emissions in the two organisations are very similar in many respects although the products are quite different.

Company 1 added to the model it received from the case study. One addition was the splitting out of actual and potential impacts into a separate spreadsheet. Another was a table of risk analysis by process area. Company 1 made better use of matrices to document information.

Company 1 did not apply an arbitrary cut off to identify significant aspects from the rest. A similar banding was observed as in the case study. Three bands were noticeable. These bands can be considered as 'very significant', 'significant' and 'not significant' as was the situation in the case study.

4.2.5 Aspects Identification and Evaluation in Company 2

Company 2 does not have an IPC licence. It is a sister company to the case study company. It set about preparing for ISO 14001 several months after the case study company. However, as there was no initial environmental review or any dedicated environmental technical support in the company progress was very slow. As part of a drive to get the company up to certification standard the case study company became actively involved in supporting the EMS development there. This afforded the opportunity to apply the same methodology as was developed in the case study. Application for assessment has been made but is not done at the time of writing this document.

Company 2 has a moulding shop and an assembly line. The product consists of plastic housings enclosing mirror shapes and attachment brackets. The brackets can be die-cast metals (bought in) or plastic (moulded in house). Some housings and brackets are painted by external suppliers and there are no in-house painting facilities. It is small by comparison with the other two companies. Although SME[2] size, it does not fit the full definition of an SME because of the ownership condition (i.e. it is *"...more than 25% owned by one or more companies that are not SME's"*). At the aspects identification and evaluation stage it did not benefit from the existence of an IPC license. The licence application is considered equivalent to a base line review under ISO 14001, Annex A. At the same time it had the typical disadvantages of SME's *("lack of resources and ready access to applicable information")*.

While the sister company (i.e. the case study company) has an environmental support function, there was none here. An initial environmental review was therefore done to complement the aspects identification and evaluation stage. A third party consultant did this.

4.2.6 Method of Transfer of Methodology – Company 2

The method / steps used to communicate the methodology to company 2 and elicit the results of its application was by direct communication, participation and observation of application and results. The methodology was summarised in presentation format. The implementation team (the management group and some key technical people from the company) were brought into a joint training and application workshop. The process was explained directly. It was then applied in stages. The case study participant acted as a trainer, facilitator, environmental technical advisor and as an observer. The same steps and sequence were followed as in the case study.

4.2.7 Comparison of Company 2 Results with Case Study

In this situation the identification method used in the case study was adopted fully. Because of the small size of the organisation it was found that a small number of people (9) spanned the functional spectrum of the company. It was decided that the identification exercise would best be done using all of those people on one team. This had the added advantage that they could also be trained together. This exercise was done in two stages. In the first stage everyone participated in selecting the aspects categories with guidance from the initial environmental review report and the case study's previous experience. The method was explained and demonstrated. The process / activity categories (active and passive as before) were assessed and documented. There was then a break of a week during which the identification stage was

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[2] Small and Medium Sized Enterprise (SME) as defined by the EU / SME Initiative.

documented formally. A summary of the comparison between the case study and company 2 is given below in Table 4.2

	Case study	Company 2
Teams	12	1
Team Participants	46	9
Man hours	150	50
Employees	450	140
Man hrs/employee	0.33	0.36
Aspects	22	14

Table 4.2 Company 2 Comparison of Aspects Identification Stage with Case Study

In the case study there were 12 teams made up of 46 team members which consisted of 24 different people (i.e. some of the same people served on different teams). In case 2 there was one team made up of 9 people, all of who participated in the full aspects identification exercise.

In the case study, the identification exercise took roughly 150 hours. This was made up of 18 hours administration (documentation) and 132 hours identifying process areas under the column matrix headings. Identification was therefore close to 3 hours per person in the case study. Those time estimates do not include time spent devising the methodology and preparing training slides, etc.

In company 2, the identification exercise took 50 hours. This was made up of 14 hours administration and 36 hours identification. Identification was 3.6 hours per person on average.

The results of the identification stage were similar for the case study and company 1. Identification time in company 2 took slightly longer per team member (3.6 hours: 2.9 hours) probably because of the higher training content per person. In the case study each person was used on two teams on average. Also, the personnel in company 2 had no exposure to environmental issues unlike the case study, which has an IPC licence. Therefore they took longer to train.

The FMEA method of aspects evaluation that was used in the case study was closely followed in company 2. The same decision rules and factoring was applied. The same method of documentation was used. The results were displayed in the same table format. Each aspect was well documented. It was therefore easy to make comparisons between aspects from the case study and company 2.

The number of aspects identified for evaluation was less than in the case study. Fourteen aspects were identified in company 2. A notable difference was the absence of different categories of hazardous waste and splits in other media emissions. For example both the case study and company 1, which are IPC licensed facilities due to VOC emissions, had split aspects for air. One split was the main process giving rise to VOC and the second was other air emissions. Such splits were not necessary in company 2.

A second observation was the lower scores obtained in the FMEA. The highest score was 324 for hazardous waste. This was about half of the highest score for the most significant aspect in the case study (612 for effluent discharge). The scores were lower in general for the S factor because the two licensed facilities always scored a '3' for legislative compliance. This was because they are regulated and 'regulated and compliant scores '3' under the decision rules. Company 2 is unregulated for the most part and where compliant would score a '1'. This shows a slight bias in the FMEA. In general the scores were lower because of the nature of the activity.

Two bands of aspect significance were distinguishable. This was because aspect scores were grouped closer together due to the lower scores of the most significant aspects. In this situation it is easier to apply an arbitrary cut-off as suggested by Bouchier *et al* (1998) and discussed above.

4.2.8 Summary of Aspects Identification and Evaluation Costs

The following table is a summary of estimated costs in man-hours. The environmental engineer provided the information for company 1. It was observed directly and recorded for the case study and for company 2.

	Case study	Company 1	Company 2
Identification	150	> 160	50
Evaluation	105	90	90
Total	255	> 250	140

Table 4.3 Summary of Man-hour costs for Aspects Identification and Evaluation

4.3 CONCLUSION

In this section the two further company cases where the methodology was applied were discussed and compared with the case study. The first of those has been successfully audited against the standard and the second is in an advanced stage of preparation. It is concluded that the described methodology can be used successfully across different organisations.

SECTION 5

SUMMARY OF METHODOLOGY AND FINDINGS

The methodology used in the case study was found to be robust, to work well and to be applicable to different companies. The methodology is shown in Fig 5.1. The process was found to be both 'top down' and 'bottom up'. Step 2 (Identification of aspects) is bottom up. It is a team-based approach. Step 3 (Evaluation of aspects) is top down.

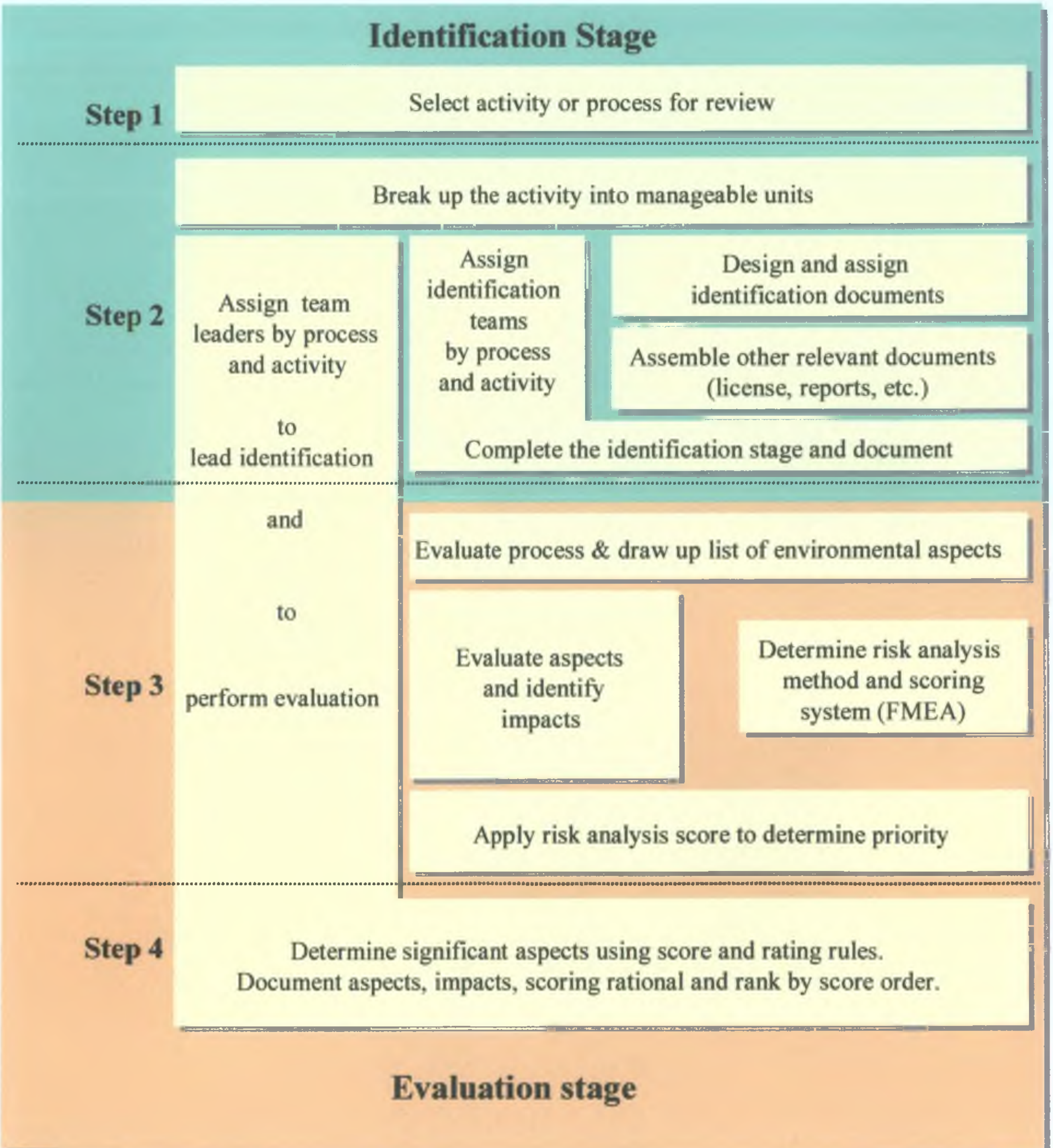

Fig. 5.1 Aspects Identification and Evaluation Methodology

Aspects identification and evaluation is not a once-off process but a repeating process. The first exercise is the most difficult. This is because of the uncertainty of how to go about it, the lack of documentation, the exhaustive search required and inexperience at rating environmental impacts. If the initial aspects review is thorough and well documented, subsequent reviews can be much easier and better supported with information. It is recommended that the initial aspects identification and evaluation be well documented.

There are many companies who have ISO 14001. Various methods of aspects identification and evaluation have been applied successfully. It is useful to benchmark successful companies from within the same or similar industry / service sectors so as not to re-invent the wheel. There is sensitivity by companies to releasing aspects information. This inhibits benchmarking.

The setting up of a file of flow charts, block diagrams and matrices summarising organisation activities from an environmental media perspective is recommended. Cross functional teams should be used. This provides a systematic information source with which to evaluate aspects, their respective impacts and to arrive at informed judgement in the risk analysis stage. It is a method of bridging the past with the future and it is not reliant on individuals.

The use of teams in the aspects identification stage also provides environmental awareness and training. It ensures an inclusive review and helps to meet the multi-dimensional requirements of the standard. Team members who review aspects may later work on teams to improve them.

Scheduled activities have IPC licence support resources, a Pollution Emission Register, an Annual Environmental Report and licence support information. They have the advantage of both summarised information and technical evaluation skills. Non scheduled activities do not have this resource. The initial environmental review in a company where there is no IPC licence often requires external technical help. This does not provide the same depth of information that is available to support an IPC licence.

The activities, products and services of an organisation are managed by the organisation's management function. The operations management function responsible for the site can impact on the environment by its management decisions. Therefore aspects identification and evaluation should take the operations management perspective into account.

Likewise, the operations management function should understand the organisation's environmental aspects. The combined effect of cascading ISO 14001 as a requirement to do business and the tightening of environmental performance criteria by legislation has important business implications. The aspects identification and evaluation exercise is a useful place for operations managers to learn the environmental realities of the business.

The number of aspects to be evaluated should be identified with some practical compromise considerations. On the one hand identification of <u>significant</u> aspects will be used to support continuous improvement objectives and targets. Therefore significant aspects should be specific enough to allow determining factors to be addressed. For example the VOC aspect may be split out into VOC aspects for different, independent processes. On the other hand efficiency of resource usage requires that the aspects list be manageable. Therefore minor aspects can be considered as one family, for example 'all other VOC'. Those two considerations require that a practical compromise be reached.

It was observed from the case study and further applications that direct activities are easier to assess than indirect aspects. Information used to assess them is under the control of the organisation. They also lend themselves to continuous improvement programmes under the direct control of the organisation applying the EMS. Indirect activities are more difficult to assess due to a lack of information from third parties. They are also more difficult to apply continuous improvement programmes to due to a lack of direct control.

It is suggested that direct aspects can be addressed faster due to direct control. Therefore indirect aspects become relatively more significant with time. Secondly, it is suggested that there are four logical classifications of indirect aspects. These are partnership and commodity relationships, each of which can have significant or insignificant environmental aspects. These distinctions should be considered when classifying indirect aspects such as supply side and other services. There is a role for the operations management function in this classification and subsequent improvement programmes.

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APPENDIX 1

EXTRACT FROM ANNUAL ENVIRONMENTAL REPORT OF CASE STUDY

COMPANY AND PRODUCTS - INTRODUCTION

Donnelly Mirrors Ltd. is part of Donnelly Corporation. Corporate headquarters is in Holland, Michigan, USA. Donnelly offers the automotive industry a wide-ranging and varied line-up of high quality, value added products. These include interior and exterior automotive mirrors and added features, such as lighting, compass, automatic dimming, etc. Donnelly Mirrors Ltd. was the first overseas manufacturing venture of Donnelly Corporation and was established in Naas in 1968. The original operation began manufacturing prisms for interior automotive mirrors in small volumes. This operation continues today in Naas with annual volumes in excess of ten million prisms. In the late eighties, prism manufacture extended to full interior mirror assembly for about 25% of prisms manufactured in Naas. More recently, an automatic dimming mirror has been developed in Naas using electrochromic (EC) technology. This EC mirror is now manufactured in Naas for interior and exterior automotive applications.

Donnelly Mirrors Ltd has always maintained a high commitment to total quality across all disciplines in the organisation. This is evident by the fact that Donnelly Mirrors Ltd. is a QS 9001 and ISO 9001 registered company. A registered auditor carries out compliance audits annually. In addition to the above standards, Donnelly Mirrors Ltd. has achieved accreditation to VDA 6.1 and to ISO 14001 in the past months. **DML received its ISO 14001 certification in December 1999.**

The main processes in Donnelly Mirrors Ltd. with environmental impact are the silvering process and wet glass grinding process. The silvering process is used to make mirror from glass. It is a wet deposition process that deposits silver on glass and protects the silver with copper and two coats of paint: a primer and a topcoat. This process gives rise to both air emissions (VOC) and to aqueous emissions (glass washings and metals run-off). The wet glass grinding process is the removal (grinding) of glass (suspended glass particles) from the mirror in order to end up with the required contoured shape and 'prism angle', giving the day/night reflective properties. Aqueous emissions are treated on site in a wastewater treatment plant. Air emissions are released unabated. For the past two years Donnelly Mirrors has been investigating alternative sources of silvered glass in order to be in a position to decommission the silvering process.

Note: this extract was taken from the AER for 1999. It was published in February 2000.

APPENDIX 2 (a)

ASPECTS RANKING SUMMARY TABLE - CASE STUDY FMEA (AS APPLIED)

FMEA Variation: (As used) Factor F x L x S where S scores total is factored back to 10 (max score = 10 x 10 x 10 = 1000)

Aspects Ranking Summary Table - Case Study FMEA (as applied)

Rank order	Aspect	F(10)	L(10)	Legal compliance	Community sensitivity	Impact on receptors	Resource depletion	Risk Management	S(10)	RPN	
1	Effluent	10	9	5	2	4	2	4	6.8	612	
2	VOC	9	9	5	2	4	3	3	6.8	551	50%
3	Haz' mats 1	8	5	5	1	5	3	3	6.8	272	
4	Haz' mats 2	8	5	5	2	3	3	3	6.4	256	20%
5	Haz' mats 3	8	5	3	1	2	2	3	4.4	176	
6	Supply side	8	5	4	1	2	1	2	4.0	160	
7	Sludge	9	4	3	2	2	2	2	4.4	158	
8	Land/aquifer	8	4	4	2	3	2	1	4.8	154	
9	Resources	9	5	2	1	1	3	1	3.2	144	
10	Main process waste	9	4	3	1	2	2	2	4.0	144	
11	Energy	9	3	3	1	2	3	2	4.4	119	
12	Packaging waste	8	3	3	2	2	3	2	4.8	115	10%
13	OHS side	4	5	3	2	3	1	3	4.8	96	
14	Surface water	4	4	4	1	3	1	3	4.8	77	
15	Design side	6	2	3	1	4	3	1	4.8	58	
16	Air (non-VOC)	4	2	5	2	3	3	2	6.0	48	
17	Sewer	4	2	3	1	3	1	2	4.0	32	
18	Odour	4	2	3	2	2	1	1	3.6	29	
19	Enviro' noise	2	2	4	2	2	1	2	4.4	18	
20	Particulates	2	2	3	1	1	1	1	2.8	11	
21	Eco-system	2	2	3	1	1	1	1	2.8	11	
22	Visual impact	2	2	3	1	1	1	1	2.8	11	

Rules: Score out of 10 for F, L and S. Bring the S factor back to 10, i.e.(5 x 5)/2.5 = max of 10
Max score = 10 x 10 x 10 = 1000
Very significant aspects = score of 20% or more, i.e 200 points or more. Aspects above 10% are significant.
Result: An approximate pareto trend 4/22 above 20% of max score; 8/22 between 10% and 20%; and 10/22 below 10% of max

APPENDIX 2 (b)

ASPECTS RANKING SUMMARY TABLE - CASE STUDY FMEA VARIANT 1

FMEA Variation: Factor F x L x S where S sub-component scores are weighted up (max score = 10 x 10 x 25 = 2500)

Aspects Ranking Summary Table - Case Study FMEA Variant 1

Rank order	Aspect	F(10)	L(10)	Legal compliance	Community sensitivity	Impact on receptors	Resource depletion	Risk Management	S(25)	RPN	
1	Effluent	10	9	5	2	4	2	4	17.0	1530	61.2%
2	VOC	9	9	5	2	4	3	3	17.0	1377	55.1%
3	Haz' mats 1	8	5	5	1	5	3	3	17.0	680	27.2%
4	Haz' mats 2	8	5	5	2	3	3	3	16.0	640	25.6%
5	Haz' mats 3	8	5	3	1	2	2	3	11.0	440	17.6%
6	Supply side	8	5	4	1	2	1	2	10.0	400	16.0%
7	Sludge	9	4	3	2	2	2	2	11.0	396	15.8%
8	Land/aquifer	8	4	4	2	3	2	1	12.0	384	15.4%
9	Resources	9	5	2	1	1	3	1	8.0	360	14.4%
10	Main process waste	9	4	3	1	2	2	2	10.0	360	14.4%
11	Energy	9	3	3	1	2	3	2	11.0	297	11.9%
12	Packaging waste	8	3	3	2	2	3	2	12.0	288	11.5%
13	OHS side	4	5	3	2	3	1	3	12.0	240	9.6%
14	Surface water	4	4	4	1	3	1	3	12.0	192	7.7%
15	Design side	6	2	3	1	4	3	1	12.0	144	5.8%
16	Air (non-VOC)	4	2	5	2	3	3	2	15.0	120	4.8%
17	Sewer	4	2	3	1	3	1	2	10.0	80	3.2%
18	Odour	4	2	3	2	2	1	1	9.0	72	2.9%
19	Enviro' noise	2	2	4	2	2	1	2	11.0	44	1.8%
20	Particulates	2	2	3	1	1	1	1	7.0	28	1.1%
21	Eco-system	2	2	3	1	1	1	1	7.0	28	1.1%
22	Visual impact	2	2	3	1	1	1	1	7.0	28	1.1%

Rules: Score out of 10 for F and L. Score S out of 25 i.e.(5 x 5) = max of 25
Max score = 10 x 10 x 25 = 2500
Very significant aspects = score of 20% or more, i.e 500 points or more. Aspects above 10% are significant.
Result: No change in ranking - everything was factored by the same amount (2.5) so points have increased.

APPENDIX 2 (c)
ASPECTS RANKING SUMMARY TABLE - CASE STUDY FMEA VARIANT 2

FMEA Variation: Factor F x L x S where S scores risk management only (max score = 10 x 10 x 10 = 1000)

Aspects Ranking Summary Table - Case Study FMEA Variant 2

Rank order	Aspect	F(10)	L(10)	Legal compliance	Community sensitivity	Impact on receptors	Resource depletion	Risk Management	S(10)	RPN	As Absolute %	Revised rank
1	Effluent	10	9	0	0	0	0	4	8.0	720		1
2	VOC	9	9	0	0	0	0	3	6.0	486	50%	2
3	Haz' mats 1	8	5	0	0	0	0	3	6.0	240		3
4	Haz' mats 2	8	5	0	0	0	0	3	6.0	240	20%	4
5	Haz' mats 3	8	5	0	0	0	0	3	6.0	240		5
6	Supply side	8	5	0	0	0	0	2	4.0	160		6
7	Sludge	9	4	0	0	0	0	2	4.0	144		7
8	Land/aquifer	8	4	0	0	0	0	1	2.0	64		14
9	Resources	9	5	0	0	0	0	1	2.0	90		13
10	Main process waste	9	4	0	0	0	0	2	4.0	144		8
11	Energy	9	3	0	0	0	0	2	4.0	108		10
12	Packaging waste	8	3	0	0	0	0	2	4.0	96	10%	11
13	OHS side	4	5	0	0	0	0	3	6.0	120		9
14	Surface water	4	4	0	0	0	0	3	6.0	96		12
15	Design side	6	2	0	0	0	0	1	2.0	24		17
16	Air (non-VOC)	4	2	0	0	0	0	2	4.0	32		15
17	Sewer	4	2	0	0	0	0	2	4.0	32		16
18	Odour	4	2	0	0	0	0	1	2.0	16		18
19	Enviro' noise	2	2	0	0	0	0	2	4.0	16		19
20	Particulates	2	2	0	0	0	0	1	2.0	8		20
21	Eco-system	2	2	0	0	0	0	1	2.0	8		21
22	Visual impact	2	2	0	0	0	0	1	2.0	8		22

Rules: Score out of 10 for F, L and S. For S, only score the risk factor and score it out of 10.
Max score = 10 x 10 x 10 = 1000
Very significant aspects = score of 20% or more, i.e 200 points or more. Aspects above 10% are significant.
Result: Similar to the original result. Less descrimination. Two aspects have moved across the significance lines. Very significant aspects are in the same order. One aspect has moved into the very significant group. Overall, nothing significant.

APPENDIX 2 (d)
ASPECTS RANKING SUMMARY TABLE - CASE STUDY FMEA VARIANT 3

Factor F x L x S where the risk management fraction is weighted up (max score = 10 x 10 x 10 = 1000)

Aspects Ranking Summary Table - Case Study FMEA Variant 3

Rank order	Aspect	F(10)	L(10)	Legal compliance	Community sensitivity	Impact on receptors	Resource depletion	Risk Management (x4)	S(10)	RPN	Revised rank
1	Effluent	10	9	5	2	4	2	16	7.3	653	
2	VOC	9	9	5	2	4	3	12	6.5	527	50%
3	Haz' mats 1	8	5	5	1	5	3	12	6.5	260	
4	Haz' mats 2	8	5	5	2	3	3	12	6.3	250	20%
5	Haz' mats 3	8	5	3	1	2	2	12	5.0	200	
6	Supply side	8	5	4	1	2	1	8	4.0	160	
7	Sludge	9	4	3	2	2	2	8	4.3	153	
8	Land/aquifer	8	4	4	2	3	2	4	3.8	120	
9	Resources	9	5	2	1	1	3	4	2.8	124	
10	Main process waste	9	4	3	1	2	2	8	4.0	144	
11	Energy	9	3	3	1	2	3	8	4.3	115	
12	Packaging waste	8	3	3	2	2	3	8	4.5	108	10%
13	OHS side	4	5	3	2	3	1	12	5.3	105	
14	Surface water	4	4	4	1	3	1	12	5.3	84	
15	Design side	6	2	3	1	4	3	4	3.8	45	
16	Air (non-VOC)	4	2	5	2	3	3	8	5.3	42	
17	Sewer	4	2	3	1	3	1	8	4.0	32	
18	Odour	4	2	3	2	2	1	4	3.0	24	
19	Enviro' noise	2	2	4	2	2	1	8	4.3	17	
20	Particulates	2	2	3	1	1	1	4	2.5	10	
21	Eco-system	2	2	3	1	1	1	4	2.5	10	
22	Visual impact	2	2	3	1	1	1	4	2.5	10	

Rules: Increrase the weighting of the risk management factor to the same as the other four S factors and factor back to 10. i.e.(5 x 4) + (5 x4) / 4 = max of 10

Very significant aspects = score of 20% or more, i.e 200 points or more. Aspects above 10% are significant.

Result: Very similar to the original result. Overall, nothing significant.

APPENDIX 2 (e)
ASPECTS RANKING SUMMARY TABLE - CASE STUDY
FMEA VARIANT 4

FMEA Variation: Factor F x L x S where S sub-components are factored (max score = 10 x 10 x 3125 = 312500)

Aspects Ranking Summary Table - FMEA Variant 4

Rank order	Aspect	F(10)	L(10)	Legal compliance	Community sensitivity	Impact on receptors	Resource depletion	Risk Management	$S(5^5)$	RPN	As Absolute %	As relative %	Revised rank
1	Effluent	10	9	5	2	4	2	4	320.0	28800	9.22%	98.8%	2
2	VOC	9	9	5	2	4	3	3	360.0	29160	9.33%	100.0%	1
3	Haz' mats 1	8	5	5	1	5	3	3	225.0	9000	2.88%	30.9%	4
4	Haz' mats 2	8	5	5	2	3	3	3	270.0	10800	3.46%	37.0%	3
5	Haz' mats 3	8	5	3	1	2	2	3	36.0	1440	0.46%	4.9%	8
6	Supply side	8	5	4	1	2	1	2	16.0	640	0.20%	2.2%	13
7	Sludge	9	4	3	2	2	2	2	48.0	1728	0.55%	5.9%	5
8	Land/aquifer	8	4	4	2	3	2	1	48.0	1536	0.49%	5.3%	7
9	Resources	9	5	2	1	1	3	1	6.0	270	0.09%	0.9%	16
10	Main process waste	9	4	3	1	2	2	2	24.0	864	0.28%	3.0%	12
11	Energy	9	3	3	1	2	3	2	36.0	972	0.31%	3.3%	11
12	Packaging waste	8	3	3	2	2	3	2	72.0	1728	0.55%	5.9%	6
13	OHS side	4	5	3	2	3	1	3	54.0	1080	0.35%	3.7%	10
14	Surface water	4	4	4	1	3	1	3	36.0	576	0.18%	2.0%	14
15	Design side	6	2	3	1	4	3	1	36.0	432	0.14%	1.5%	15
16	Air (non-VOC)	4	2	5	2	3	3	2	180.0	1440	0.46%	4.9%	9
17	Sewer	4	2	3	1	3	1	2	18.0	144	0.05%	0.5%	17
18	Odour	4	2	3	2	2	1	1	12.0	96	0.03%	0.3%	19
19	Enviro' noise	2	2	4	2	2	1	2	32.0	128	0.04%	0.4%	18
20	Particulates	2	2	3	1	1	1	1	3.0	12	0.00%	0.0%	20
21	Eco-system	2	2	3	1	1	1	1	3.0	12	0.00%	0.0%	21
22	Visual impact	2	2	3	1	1	1	1	3.0	12	0.00%	0.0%	22

Rules: Score out of 10 for F and L. Instead of adding the S factors, multiply them i.e.(5^5) = max of 3125

Max score = 10 x 10 x 3125 = 312500

Very significant aspects = score of 20% or more, i.e 62500 points or more. Aspects above 10% are significant.

Result: Percentage cut off is much lower. Ranking has changed but not so significantly as to make any great difference. A few notable changes (supply side and resources moved up in priority and non VOC air moved down) but no overall changes.

APPENDIX 3

ENVIRONMENTAL ASPECTS / TARGETS MATRIX

Objectives →		1				2				3			4	5		6		7		8			9
Ranking	Aspects \ Targets	Target 1	Target 2	Target 3	Target 4	Target 5	Target 6	Target 7	Target 8	Target 9	Target 10	Target 11	Target 12	Target 13	Target 14	Target 15	Target 16	Target 17	Target 18	Target 19	Target 20	Target 21	Target 22
1	Effluent discharge	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓			✓	✓	✓	✓				✓
2	Air emissions – solvents from silvering				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	✓	✓	✓	✓	✓
3	Hazardous mat's / waste solvents					✓	✓	✓		✓	✓	✓	✓	✓	✓					✓	✓	✓	✓
4	Other Hazardous Materials					✓		✓	✓	✓	✓	✓	✓										✓
5	Hazardous Waste – 1					✓	✓		✓				✓	✓	✓								✓
6	Suppliers and sub contractors	✓	✓			✓		✓					✓	✓				✓	✓	✓	✓	✓	✓
7	Glass fines filter cake	✓	✓	✓	✓	✓		✓	✓				✓		✓								✓
8	Contaminated land	✓											✓										✓
9	Resource usage	✓		✓		✓		✓					✓	✓		✓	✓	✓					✓
10	Glass and mirror cuttings					✓		✓	✓				✓	✓									✓
11	Energy					✓		✓					✓	✓		✓	✓	✓					✓
12	Other non hazardous waste including packaging	✓				✓		✓	✓				✓	✓									✓
13	Occupational exposure (noise / chemicals / dust / radioactivity)									✓	✓	✓	✓										✓
14	Surface water emissions	✓								✓	✓	✓	✓						✓				✓
15	Product design												✓	✓						✓	✓	✓	✓
16	Air emissions – all other									✓	✓	✓	✓										✓
17	Sewer emissions	✓											✓			✓	✓						✓
18	Odour												✓										✓
19	Environmental noise												✓										✓
20	Particulate												✓										✓
21	Eco-system	✓											✓						✓				✓
22	Visual Impact												✓										✓

Modification of matrix used by case study for setting objectives and targets against aspects. This shows how environmental aspects are matched with environmental targets. The more significant aspects have more targets to address them.

✓ *'that target addresses that aspect.'*

✓✓✓ (shaded) *'all targets supporting that objective address that aspect.'*