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Environmental Protection Standards at Petrol Stations:
A Comparative Study Between Finland and Selected European Countries

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Knowledge is argued true belief (Plato)

ABSTRACT

This study compares environment protection standards at Finnish petrol stations with levels in nine other European countries. The countries selected for comparison and the collection of data were: Germany, Hungary, Lithuania, Norway, Poland, Russia, Spain, Sweden and United Kingdom. With the exception of Norway and Russia, all these states are members of the European Union. Together, they provide a representative cross-section of Europe countries on which to base a comparison with Finnish levels of environmental protection. Three of these countries, Norway, Russia and Sweden, also share a common land border with Finland.

The main method used in the study was sampling research. Major research materials included risk analysis, an extensive questionnaire with respondent feedback and a practical field investigation of each country. It is hoped that the outcome of this study will be of benefit to stakeholders in this sector of the oil industry such as the regulatory authorities, oil companies, contractors and designers.

The methods adopted here confirmed that it is possible to evaluate environment protection levels in Finland and compare them internationally. The results show that in Finland such levels were lower than initially expected. Though Finnish levels were found to be higher than in Norway and Russia and similar to Sweden, they were markedly lower than in Germany and Hungary and lower than in Lithuania, Poland, Spain and United Kingdom. The results indicate a clear need to improve standards of environmental protection at Finnish petrol stations.

Discounting Sweden and Norway, the main reason that Finland performs poorly in such international comparisons of environmental protection is its lax legislation. However, it was noted that Finnish oil companies are prompt in adopting new rules and regulations. This strongly suggests that in Finland legislation may be the best way to improve environment protection at petrol stations.

The results of this study are expected to provide practical guidelines for the Finnish oil industry. Environment protection at Finnish petrol stations could be improved by legislation requiring the installation of vapour recovery stage 2-systems, 2-wall tanks instead of 1-wall tanks, better pavement materials, periodic inspection processes and the validation of professional qualifications of designers and contractors. This study also shows that there is scope for further research in the field.

It is hoped that the research carried out here will provide the impetus for further study in the crucially important area of environment protection at petrol stations.

Keywords: Petrol station, environment protection, BAT, release source, legislation, environmental risk analysis.

FOREWORD

The present thesis is the outcome of many years practical experience gained in the oil industry coupled with a desire to transfer this knowledge into scholarship. It is hoped that this study will provide an insight into a field which has largely been overlooked in academic research. This study of environment protection at petrol stations was conducted at the Laboratory of Engineering Geology, Department of Civil Engineering at Tampere University of Technology.

I wish to thank Professor Raimo Uusinoka for supervising the work and for his help and guidance throughout its progress. I would also like to thank Dr. Kirsi Levä of the Safety Technology Authority for her valuable suggestions and professional advice. Thanks are also due to Professor Tom Frisk of Pirkanmaa Regional Environment Centre, Dr. Antero Honkasalo of the Ministry of Environment and Dr. Kari Koponen of Golder Associates Ltd for reading the manuscript so thoroughly. I am grateful to them all for their constructive criticism and valuable observations.

My special thanks are due to Ilpo Lahtinen whose company's financial support has made this research possible. I am also indebted to Wawin-Labko Oy and all those companies who contributed so much valuable practical support. I would like to thank Alan Thompson MPhil for revising the English language text. I would also like to express my warmest thanks to the staff of Tampere University of Technology, especially the members of the Department of Civil Engineering. Their helpful responses to my numerous enquiries provided an important source of input.

The international sampling research involved a vast number of people. I would like to thank all the respondents from the countries involved: Germany, Hungary, Lithuania, Norway, Poland, Russia, Spain, Sweden and United Kingdom. I am especially grateful to those individuals who put me in touch with all the "sensible and conscientious respondents" in these countries. I wish to express my gratitude to Pekka Huttula of the Finnish Oil and Gas Federation, Matti Peltonen of Coteba Finland, Thomas Andersson and Staffan Helleday of Kungörs Plast Ab, Sweden as well as Mr. David Holmes of Fibrelite Composites Ltd, United Kingdom.

In nineteen years working and studying in the oil industry, I have met many people from all over the world. Many of these have since become firm friends and colleagues, sharing their knowledge and experience with me in this research. My thanks go to all the designers and contractors, material producers and authorities for making the oil industry such a stimulating environment to work in.

Greatest thanks of all go to my nearest and dearest: To my wife, Kirsi for her unstinting support and kindness as well as to the future builders of a cleaner and healthier globe; my children Ville, Jaakko and Ella. I hope I have shown them here that dreams can come true.

Tampere 31st of March, 2005

Pasi Nieminen

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TERMINOLOGY AND ABBREVIATIONS

APEA the Association for Petroleum and Explosives Administration

API American Petroleum Institute

BAT Best Available Techniques

Bentonite A material composed of clay minerals, predominantly montmorillonite with minor amounts of other smectite group minerals, commonly used in drilling mud. Bentonite swells considerably when exposed to water, making it ideal for protecting formations from invasion by drilling fluids. Montmorillonite forms when basic rocks such as volcanic ash in marine basins are altered.

BREF BAT Reference Document

BTEX-compounds
Benzene, toluene, ethyl benzene and xylenes; components of petrol and diesel oil.

CEC Coordinating European Council for the Development of Performance Test for Lubricants and Engine Fuels

CEN European standardisation organization. Deals with all areas of standardisation except electrical and telecommunication standards.

Chamber/Manhole
A chamber in an underground tank. It might also contain pipes, valves, level gauge junctions and other installed equipment. It is covered with a lid. Also known as ***sump***, ***manhole***, ***inspection well*** and ***maintenance well***.

CONCAVE The Oil Companies' European Organisation for Environment, Health and Safety.

Dipstick A measuring rod to determine the level (height) of a fuel product inside a storage tank. It is used for taking measurements manually.

Dispenser Equipment used for transferring a fuel product from a storage tank to a customer's vehicle.

EEA European Environment Agency

EIPPCB European Integrated Pollution Prevention and Control Bureau

EN European Standard

EPTC European Petroleum Technical Co-operation

EU European Union

EURO-FUEL European Fuel Association

EUROPIA European Petroleum Industry Association

Factitious compaction structure
The layer under the pavement that is constructed for protecting the ground; usually made of HDPE-membrane but could also be made of bentonite.

FIN Finland, Finnish

Filling pipe A pipe for transferring a fuel product from a tanker to a storage tank. The top of the filling pipe is the connection point for a tanker’s hose.

Filling sump The shaft in which the top part of the filling pipe is located. This could also be called ***filling well***, ***filling box***.

Forecourt An area used by customers while filling their vehicles. Pump islands and dispensers are located here.

Fuel filling area
An area used by tankers while filling storage tanks. The top parts of the filling pipes and/or filling sumps are located here.

GER Germany, German

HDPE High density polyethylene

HUN Hungary, Hungarian

IP the Institute of Petroleum

IPE International Petroleum Exchange

KTM Ministry of Trade and Industry (FIN)

Leak detector of double-wall tanks
Electrically operated alarm device that emits an alarm signal to a control unit in the event of a leak in one or the other wall of a storage tank.

LT Lithuania, Lithuanian

MTBE Methyl tertiary-butyl ether; is a chemical compound produced by the chemical reaction of methanol and isobutylene. MTBE has been used in fuel to replace lead as an octane enhancer. At room temperature, MTBE is a volatile, flammable and colourless liquid that dissolves rather easily in water.

Monitoring well
A well for observing the conditions in underground spaces.

NOR Norway, Norwegian

Oil Industry In the present study it denotes that sector of the oil industry relating specifically to petrol station operations.

Oil separator A well that is connected to a drainage system. Separates oil and solids from rain water.

Oil Separator Alarm Device
Electrically operated device that emits an alarm signal to a control unit when the oil space of the separator is nearly full or the liquid level increases due to a blockage or an obstruction or there is a layer of sand and other solids on the bottom.

Overfill prevention
Equipment that halts the transference of a fuel product from a tanker to a storage tank when the tank is full. Can be an electronic or mechanical system.

PE Polyethylene

PEI Petroleum Equipment Institute

Petrol Station An area including fuel equipment and piping, storage tanks, forecourt and possible building premises for the sale of fuel (flammable liquids) to customer’s vehicles. Could be called also ***Distribution Station***, ***Filling Station***, ***Fuel Station***, ***Gas Station***, ***Gasoline Station, Service Station*** and ***Traffic Station***.

PL Poland, Polish

Pump island Base for the dispenser.

RUS Russia, Russian

Sample shaft A well connected to a drainage system after the oil has passed through the separator. Used for sampling water.

Sand separator A well that is connected to a drainage system on the forecourt and fuel filling area for collecting rain water and separating sand and other solids from the water.

SARA Risk Analysis for Accidental Releases - SARA

SFS Finnish Standards Association. When the letters SFS are written together with a numerical code it refers to a specific standard that is confirmed by the Finnish Standards Association, e.g. SFS 3352.

SM Ministry of the Interior (FIN)

Soili programme
A Finnish programme for implementing remediation of the soil of land on sites of disused petrol stations. Members of the programme are the Ministry of the Environment, the Union of Finnish Municipalities, the Finnish Oil and Gas Federation, Esso, Neste Marketing, and Shell, SOK, Teboil and Tradeka.

SP Spain, Spanish

SPI Swedish Petroleum Institute

STM Ministry of Social Affairs and Health (FIN)

Storage tank Fuel product’s storage tank, usually made of steel and installed underground. Capacity usually 10 000 – 60 000 liters.

Suction pipe Pipe for transferring a fuel product from a storage tank via a dispenser to a customer’s vehicle.

SWE Sweden, Swedish

SYKE Finnish Environment Institute; organization of specialists working under the Ministry of the Environment

TAME Tertiary amyl-methyl ether; a chemical compound manufactured by the chemical reaction of methanol and isobutylene. Used in fuel to replace lead as an octane enhancer.

Tank Level Gauging System
Electronically operated system that automatically measures the level of the fuel product inside the storage tank.

Tanker Oil tanker (truck) that delivers fuel products to a Petrol Station

TC Technical Committee

TUKES Safety Technology Authority

UK United Kingdom

Vapour recovery stage 1-system
Vapour recovery stage 1-system is the process when vapour is collected and returned to a tanker when filling the storage tanks.

Vapour recovery stage 2-system
Vapour recovery stage 2-system is the process when vapour is collected and returned to a storage tank when filling a customer’s vehicle.

Vent pipe A pipe provided for a tank’s venting system. Necessary to prevent tank distortion due to variations in internal pressure resulting from normal operational filling and emptying.

VN Government (FIN)

VOC Volatile organic compounds.

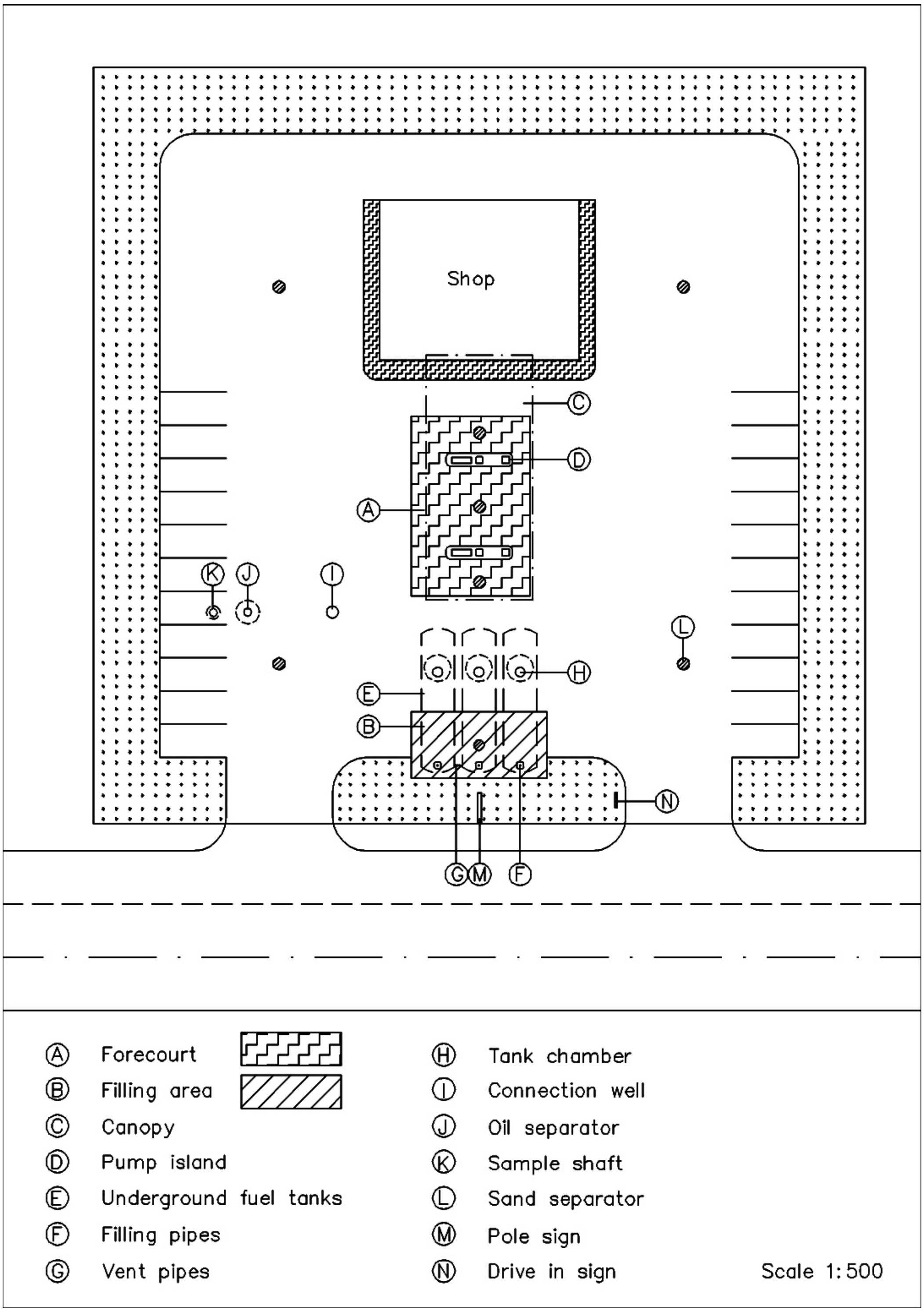
YM Ministry of the Environment (FIN)

ÖKKL Finnish Oil and Gas Federation.

1-wall Tank or pipe that has one wall. Also referred to as **1-skin** or **1-mantle**. The number “1” could be replaced by the term “single”, as in ***single wall***.

2-wall Tank or pipe that has two separate walls. Also referred to as ***2-skin*** or ***2-mantle***. The number “2” could be replaced by the term “double”, as in ***double wall***.

GENERAL SITE PLAN OF THE PETROL STATION



1. INTRODUCTION

1.1 General

Wherever there are roads, streets and cars there are also petrol stations. This research deals with the environment protection standards relating to petrol stations.

Despite the fact that petrol stations are an indispensable part of a modern technological society, they also pose numerous risks and threats to the environment. Each petrol station presents a wide range of potential challenges to the health and safety of people and their surroundings. The major environmental risks involve release sources from petrol stations which endanger the air, soil and water.

Volatile organic compounds (VOC) are responsible for pollution not only of the air but also soil and water. Particularly hazardous are the chemical additive compounds of petrol, such as MTBE and TAME. These belong to the group of VOC which are very toxic and harmful to ground water. BTEX-compounds, which pass easily into the natural environment, cause pollution of soil and water.

However, despite the many environmental dangers posed by such hazardous compounds, much can be done to offset their worst effects. Professional intervention using technology can provide environmental protection solutions and also diminish the degree and extent of environmental damage. The use of appropriate technology and professional skills can do much to alleviate and control the worst aspects of the pollution and damage caused to the environment by petrol stations.

The term ***petrol station*** has numerous synonyms. There are many international terms such as distribution station, filling station, fuel station, gas station, gasoline station, service station and traffic station used in different contexts to mean much the same thing. Throughout the present study the term *petrol station* has been used because of its explicit reference and long association with the subject, particularly within Europe.

As such, a petrol station site typically includes a wide range of facilities and equipment and also forms the location for numerous related activities and tasks. An illustration of a typical petrol station site is presented in Figure 1.1 and also in the General Site Plan of a Petrol Station on page 14.

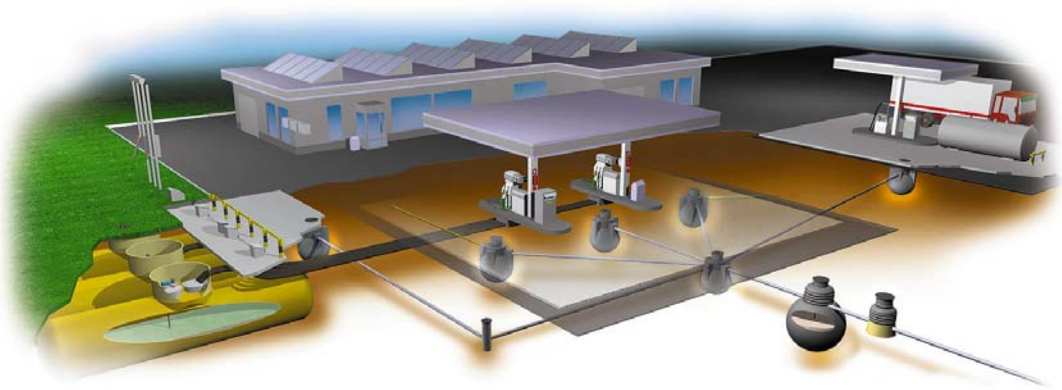


Fig. 1.1. General illustration of a Petrol station [Nieminen, P., Viitanen, H. & Labko Oy. 2001].

1.2 Development of the petrol station network in Finland

At the end of 2003 there were 1894 petrol stations in Finland [19, 20]. This figure includes both manned and unmanned petrol stations registered in the Finnish Oil and Gas Federation’s statistics. This figure does not however include truck points and private petrol stations operated by such groups as transportation companies, earth building contractors and farmers.

The greatest number of petrol stations in the Finnish network was in the 1970s when statistics were first collected. This provides the starting point for a historical comparison as shown in Figure 1.2 below. [19, 20]

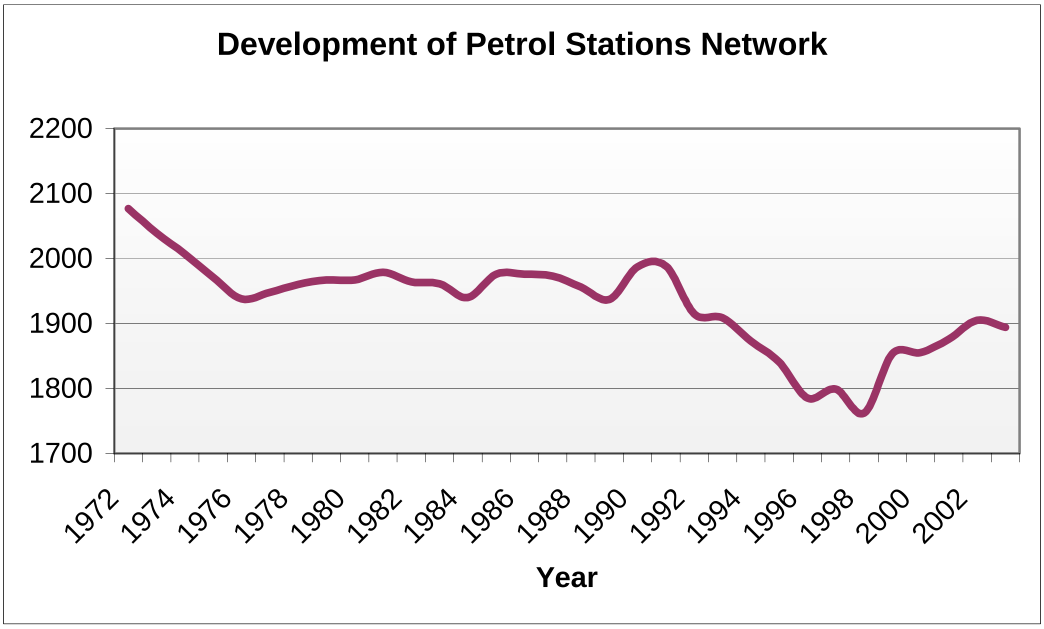


Fig. 1.2. Development of petrol station network in Finland.

Figure 1.2 does not, however, show the exact number of petrol station closures and removal from the statistics. One reason for this is that new petrol station projects are being carried out continually. Another reason is that every year there have been some hundreds of fully functioning petrol stations which have never been officially registered and thus do not appear in the statistical records. Figure 1.2 shows the general development trend of the petrol station network.

With the exception of Finland, the number of petrol stations decreased dramatically between 1970 – 1985 in all Western European countries with an overall decrease of 40–60 %. During the same period in Finland, however, the decrease in the number of petrol stations was much smaller, at only 3 %. It was not until the 1990s that numbers began to decline significantly in Finland, though even then this remained under10 %. The main explanation for such development was the economic situation. Between 1970 and 1985 the trend elsewhere in Western Europe was towards operations involving bigger units with a consequent increase in petrol station capacity. As a result, smaller petrol stations closed down in the face of stronger competition and diminished profitability. [20]

During the last ten years, hundreds of petrol stations have closed down in Finland. There are two main reasons for this. Firstly, the introduction of more rigorous legislation has made it difficult for all petrol station operators to comply with the new requirements and many have been forced to close down. Additionally, because of contamination many stations have been taken out of service. [20]

Despite the rate of petrol station closures in Finland, there has been a corresponding increase in the number of new construction starts during last ten years. A considerable proportion of these new starts are for unmanned petrol stations which, for commercial reasons, are becoming increasingly popular with the operators. Today almost all oil companies have a large number of these unmanned facilities as part of their networks. The arrival of new oil companies in Finland has naturally meant an increase in the construction of new petrol stations. Within the last decade 3-4 new oil companies or brands have entered the Finnish market and this has resulted in the construction of about one hundred new petrol stations annually [30, 31, 32]. The first unmanned petrol stations were introduced in 1990 according to registered statistical information. From 1990 until 2003 there was a total of 762 unmanned petrol stations which were either newly constructed or converted from formerly manned installations [20].

As already mentioned, hundreds petrol stations have closed down during the last ten years because of their high levels of contamination. A proportion of these have been closed by their owners, the oil companies. A large number, however, have been forced to cease their operations in consequence of the Soili programme [20, 28].

1.3 Contaminated petrol stations

Since the mid-90s soil contamination has become an increasingly important environmental concern and a topic of interest not only to conservationists but to the public at large. During the last decade the sites of hundreds of petrol stations in Finland have been cleaned and remediated. These measures have been implemented not only at existing petrol stations but also at the sites of those which no longer exist. [20, 28, 58]

Remediating a contaminated petrol station site is a very expensive undertaking. During the next twenty years (2005-2025), it is estimated that in Finland the annual cost of the remediation of contaminated land areas will be roughly 50-70 million euros. The total cost of this work will, therefore, reach some 1,2 billion euros. This figure covers not only petrol stations but also sawmills, wood preservation plants, industrial sites, depots, garages, greenhouses and shooting ranges. However, the major share of these costs will be allocated to the remediation of petrol stations. In 2003 petrol stations accounted for 44 % of the total amount of contaminated areas. [58]

In Finland the estimated cost of remediating petrol station sites during the period 2005-2025 will be approximately 25 million euros. This figure represents about 2 % of the total cost involved in remediating all contaminated land areas. About 500 petrol stations will remediated in Finland during the next twenty years, which amounts to 8 % of the total remediated land area in the country. [58]

It has been estimated that there are around 400 000 contaminated sites in Europe. The total cost of remediating these will be in the region of 109 billion euros [58].

Soili programme

In Finland the Soili programme was set up specifically for implementing remediation of soil of land on the sites of disused petrol stations. The programme is the outcome of an agreement concluded between the Ministry of the Environment, the Union of Finnish Municipalities, the Finnish Oil and Gas Federation, Esso, Neste Marketing, and Shell. Teboil, SOK and Tradeka have subsequently also become signatories to the agreement. The Oil Industry’s Service Centre together with the environment authorities oversee the Soili programme’s practical activities. [20]

Under the Soili programme work is in progress or has started on remediating over 250 petrol stations in Finland and so far, work has been completed on 230. Soil investigation surveys have also been carried out at a total of 400 petrol stations. About 40 remediation projects are to be undertaken annually. [20, 28]

The member companies finance the Soili-programme and a special oil protection fund has also been set up which is administered by the Ministry of the Environment. In recent last years many million euros per year have been spent on surveying, cleaning and reconditioning old petrol stations. During the period 1997-2004, total remediation expenditure under the Soili programme amounted to about 37 million euros. Annual expenditure of the Soili programme for this period is presented in Figure 1.3. [19, 20]

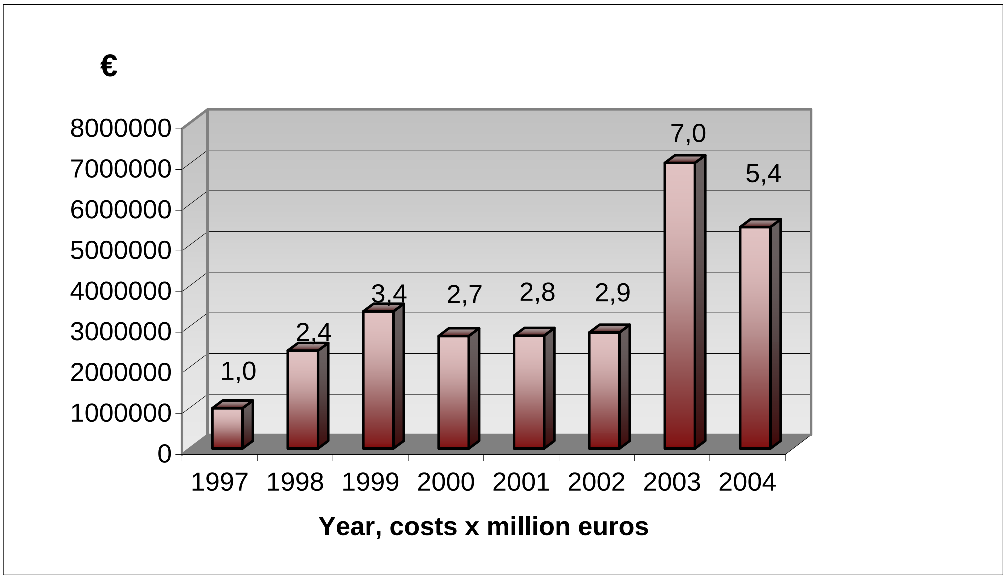


Fig. 1.3. Annual costs of Soil programme for the investigation, cleaning and remediating of old petrol stations in Finland.

Under the Soili programme the participating oil companies are responsible for covering the costs of soil investigation surveys as well as remediating their own petrol stations and sites. The Ministry of the Environment's oil pollution fund covers only the costs of remediation projects carried out on disused petrol station sites and on those sites where it is impossible to determine the origin of the contamination. The underlying principle of the Soili programme agreement is that none of the remediated sites should revert to their former use as petrol stations.

Figure 1.4 presents the annual number of petrol stations in the Soili programme which have either already undergone complete remediation or where remediation is underway.

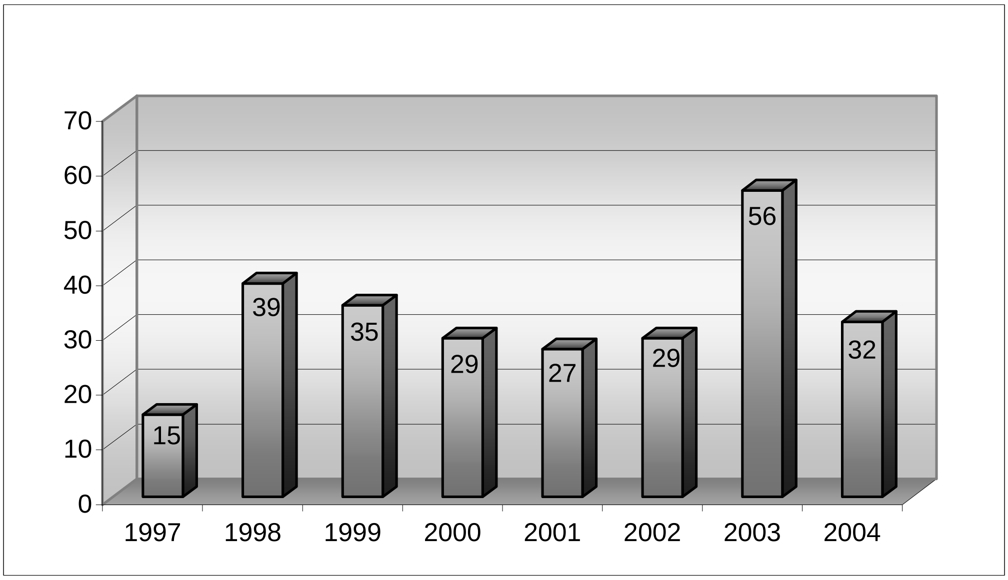


Fig. 1.4. The amount of annual remediated petrol stations in the Soili programme.

By the end of 2004 there were almost 550 applications to participate in the Soili programme. However, there are still a large number of petrol station sites whose soil conditions have not yet been investigated. [28]

It should be emphasised here that the number of petrol stations that have already been remediated under the Soili programme accounts for less than half the total number of remediated petrol station sites in Finland. In 2003, for which the most recent figures are available, there were a total of 191 remediated petrol station sites. As Figure 1.4 shows, the number of remediated petrol station in the Soili programme stood at 56, which represents about 30 % of the total. Total remediation costs in 2003 were 9.5 million euros and the Soili programme accounted for about 5.5 million euros of the total amount.

Programmes similar to the Soili programme have also been set up in Sweden and Denmark [29].

Clearly there is a need for greater research and study which, from the economic point of view, should be done sooner, rather than later. While the environmental damage caused by soil contamination at petrol station sites can never be totally eradicated much can be done to diminish the severity of its impact. This can best be achieved through careful planning and implementing the appropriate measures. Indeed, there is still much room for improvement in this field of environment protection.

It is not the purpose of the present study to investigate in any depth the subject of soil contamination or to perform a chemical analysis of the compounds responsible for such contamination. The purpose in this Section is to demonstrate the importance of finding and implementing better solutions for a healthier environment.

1.4 Theoretical approach

The theoretical approach is based mainly on *risk analysis*. Another important starting point has been *BAT (The Best Available Techniques).*

For the purpose of this study, risk analysis was carried out to identify the equipment and facilities most likely to pose a threat to the environment. Once these potential release sources and hazards have been determined, it should then be possible to devise appropriate technological solutions to avoid or minimise such risks.

A possible alternative to risk analysis could be life cycle assessment. However, the reason for choosing risk analysis over life cycle assessment is that risk analysis provides a better chance for discovering the technological solutions for improving and developing environment protection. In the researcher's view, risk analysis will be less vulnerable to error than life cycle assessment of petrol stations' equipment and activities. Identifying points for international comparison would be more problematic using a life cycle assessment approach. Such an approach would be more complicated, and applying it to the field of petrol stations would not necessarily guarantee results that would permit an international comparison to be made. Moreover, the outcome of a study based on risk analysis would have greater practical value.

Risk analysis has many advantages in that it is both systematic and practical. It makes it possible to identify the possible release sources. After these release sources have been determined and preventative technical solutions implemented, it will then be possible to compare legislation and regulations. However, it must be admitted that there are also certain drawbacks to risk analysis in that not all the risk factors are necessarily uncovered. Nonetheless, it is believed that this study, through its use of risk analysis, identifies the major risks and release sources to yield reliable and worthwhile research findings. A detailed description of risk analysis is given in Section 3.2.1.

Risks posed by traffic, land use and construction processes remain beyond the scope of the study because the essential part of the risks and release sources are directly attributable to the functions performed at the petrol station site.

Another key element in the theoretical approach is BAT. As will be shown later in this study, The Environmental Protection Act 86/2000 [12] states that BAT should always be adopted at petrol stations.

Together, ***risk analysis*** and ***BAT*** comprise the theoretical approach that makes possible a comparison of environment protection levels in Finland.

1.5 Environmental Risk Analysis

The field of environmental risk analysis covers a wide area of safety technology and embraces a multiplicity of different engineering branches.

In the present study environment risk assessment plays a minor yet significant role. Especially relevant here is the “Environmental Risk Assessment Space” devised by Fairman and Mead [17] which makes it possible to consider the position of the petrol station in the overall assessment of risk. Their Typology of Risk Assessment is presented in Figure 1.5.

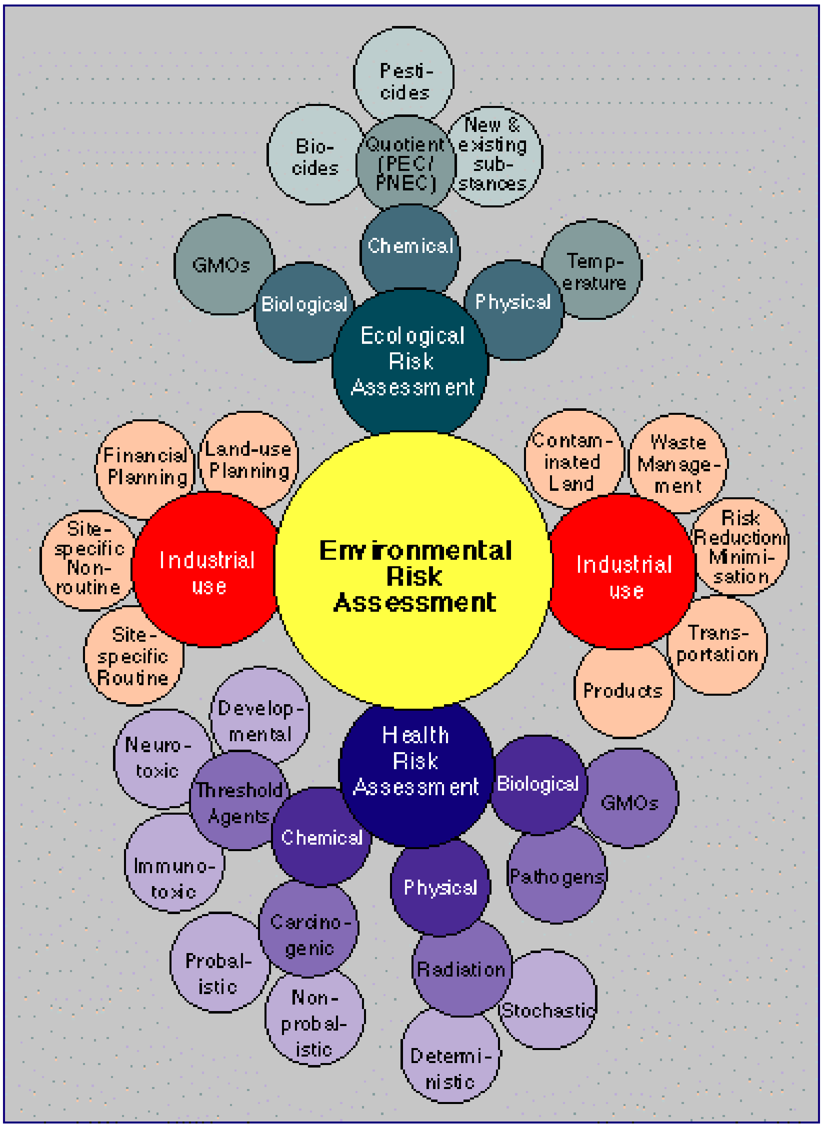


Fig. 1.5. Typology of Risk Assesment [17]

As Figure 1.5 shows there are a considerable number of fields which fall within the domain of Environmental Risk Assessment. According to the above diagram, the petrol station falls within the environmental risk assessment field entitled **Site-specific, Non-routine.** The theory of risk assessment provides a helpful schema for the identification of environmental risks and potential hazards.

Risk Management Framework and Modelling Problem

How are the risks to be managed in a modern society? The bottom levels in society are much more dynamic than those of the upper levels. Rasmussen [56] has developed a socio-technical system that is discussed below.

Rasmussen's [56, 57] framework for risk management adopts a broad systems perspective, identifying the various actors - both individuals and organizations - in a complex socio-technical system. Figure 1.6 below provides a representative sample, although the precise number of levels and their labels can vary across industries. For example, in the context of the oil industry, this hierarchy would include, from bottom to top: petrol stations and their functions, designers and contractors, municipal authorities and oil company managers, oil-companies and regional authorities, government and the media. Knowingly or not, each of these individuals and stakeholders makes decisions that affect the environment.

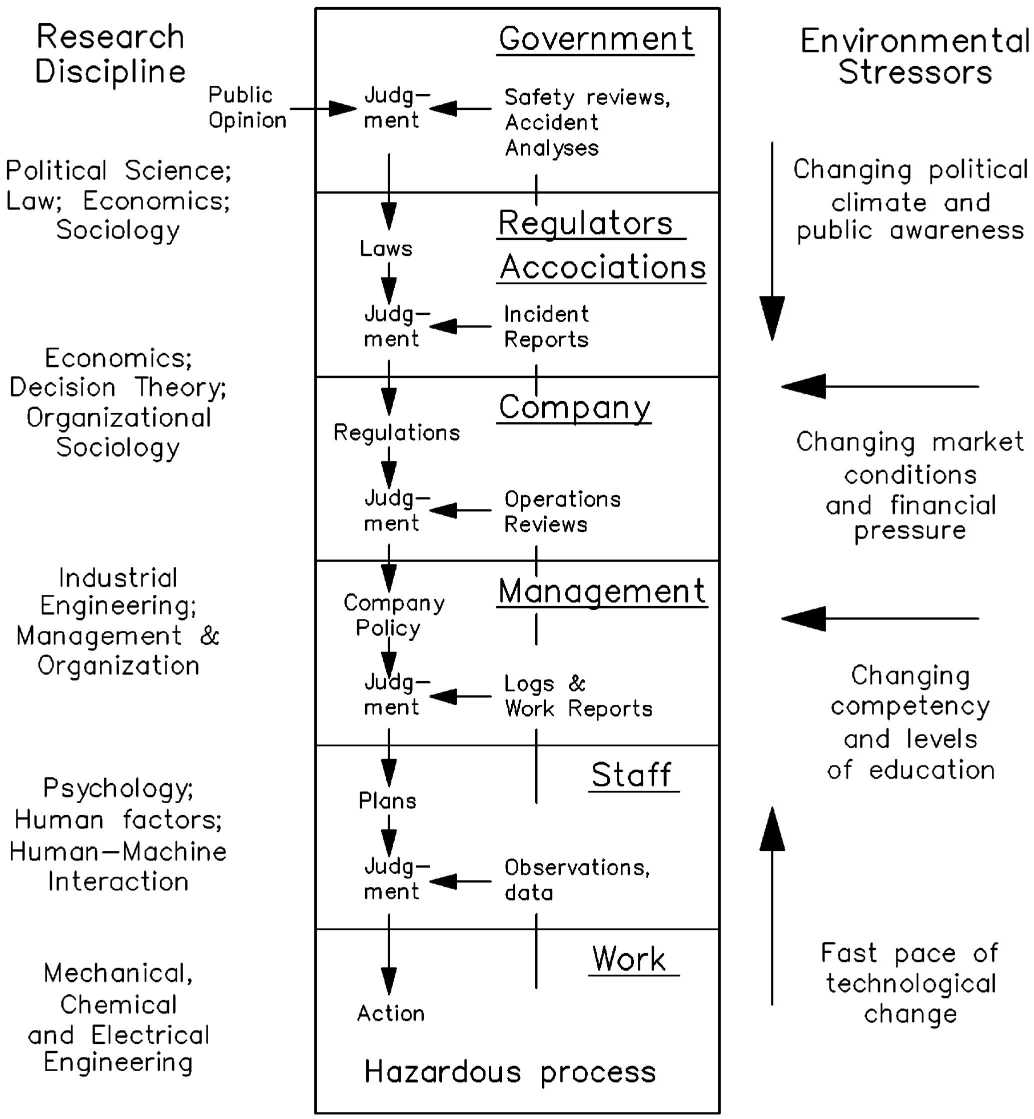


Fig. 1.6. The socio-technical system involved in risk management [56].

This framework points to a critical factor that is overlooked by all horizontal research efforts - the additional need for "vertical" alignment across the levels in Figure 1.6. Decisions at higher levels should propagate down the hierarchy, whereas information about the current state of affairs should propagate up the hierarchy. These interdependencies across levels of the hierarchy are critical to the successful functioning of a system as a whole. Even if researchers do an excellent job at conducting horizontal research on a particular topic, they may have little impact on reducing risk unless vertical integration is also achieved.

Unfortunately, the holy grail of vertical integration is becoming more important yet more difficult to achieve. As shown on the right of Figure 1.6, the various layers of a complex socio-technical system are increasingly subjected to external disruptive forces. In today's dynamic society, these external forces are stronger and change more frequently than ever before. When different levels of the system are being subjected to different pressures, each operating at different time scales, it is imperative that efforts to improve safety within a level be coordinated with the changing constraints imposed by other levels.

Rasmussen's framework can be used to identify why accidents occur and it outlines a number of broad system design implications that can be adopted to reduce risk in complex socio-technical systems, thereby safeguarding the public and the environment.

1.6 Best Available Techniques (BAT)

The Environmental Protection Act 86/2000 [12] states that within industrial operations, where contamination of the environment is possible (as indeed it always is at petrol stations), Best Available Techniques (BAT) should be applied. According to this act [12] 43 §, the granting of environment permits must be based on BAT and according to the act [12] 9 §, the applicant must also demonstrate familiarity with the principles of BAT. In other words; an application must include an evaluation of how BAT will be applied in the circumstances for which the permit is being sought.

The Environmental Protection Act 86/2000 [12] 3 § defines BAT as follows:

> "*Best available technique* refers to methods of production and treatment that are as efficient and advanced as possible and technologically and economically feasible, and to methods of designing, constructing, maintenance and operation with which the pollutive effect of activities can be prevented or most efficiently reduced."

Further, the Environmental Protection Decree 169/2000 [13] stipulates that, when evaluating the contents of BAT according to Environmental Protection Act [12] 37 §, the following issues must be addressed:

- reduction of the quantity and harmful impact of waste,
- the hazard level of employed substances and the scope for using less hazardous alternatives,
- the scope for recovery and re-use of substances used and waste generated in production processes,
- the quality, quantity and impact of discharges,
- the quality and consumption of raw materials used,
- energy efficiency,
- prevention of operational risks and the risks of accident, and damage limitation in the event of an accident,
- the time needed for introducing the best available techniques and the importance of the planned time for launching operations, plus the costs and benefits of limiting and preventing discharges,
- all impacts on the environment,
- all the methods in use on an industrial scale for production and for controlling discharges,
- developments in technology and natural science and

- information on best available techniques published by the Commission of the European Communities or international bodies.

No BAT Reference Document (BREF) or national BAT-report has yet been drafted for petrol stations in Finland although BREF's have been issued for oil refineries. At petrol station construction projects, BAT has to be applied according to the Environmental Protection Act [12]. BREF's do not contain regulations or restrictions as such, but do include information on the technology used in the branch of the industry concerned, as well as levels of consumption and emissions.

As already mentioned, another sector of the oil industry, fuel storage, has come under the eye of the regulators. In November 2004, the European Integrated Pollution Prevention and Control Bureau (EIPPCB) produced the Final Draft Reference Document on Best Available Techniques on Emissions from Storage [18]. After approval by the European Commission it is scheduled to become the accepted BREF-document. However, despite the fact that petrol stations also form part of the oil industry, this BREF cannot be applied to petrol stations notwithstanding the technological comparability of these sectors of the oil industry.

Though BAT principles do not play a fundamental role in this study, their significance is that they provide a useful means for evaluating and comparing Finnish environmental protection levels. As already stated, according to Environmental Protection Act [12], BAT has been applied in all branches whenever an environment permit is being sought. From the list of recommendations presented above, taken from the Environmental Protection Decree [13], the following issues are the most relevant here for the application of BAT-principles:

- the quality, quantity and impact of discharges,

- prevention of operational risks and the risks of accident, and damage limitation in the event of an accident and

- overall impact on the environment.

For the purposes of the present study, BAT-principles are interpreted in environmental terms as meaning that a worse and/or more dangerous technical solution should be always rejected whenever there exists a better alternative which is economically feasible. However, it is still the case that BAT-principles have no authority to enforce the use of any particular type of technology. This means that technological suitability is determined according to levels of consumption and releases. Furthermore, in evaluating BAT, factors such as local conditions, size of location and lifetime must also be taken into account. This may even require expensive solutions in certain special environmental circumstances.

In the opinion of the author, economic feasibility corresponds to a maximum of an additional 20 % of the total cost of the constructed petrol station. In practice, installation of 2-wall tanks instead of 1-wall tanks and equipping the petrol station with vapour recovery stage 2-system will only increase costs by 2-10 % depending on the size of the petrol station.

1.7 Previous studies

There is a paucity of academic research in the field of air, soil and water contamination caused by petrol pollutants. However, there are two Finnish studies worth mentioning in this context. The first is the doctoral thesis of Halmemies, 2003: *Development of a Vacuum-Extraction Based Emergency Response Method and Equipment for Recovering Fuel Spills from Underground.* [27]. The second study is the licentiate thesis of Paatonen, 1996: *Soil gas as indicator of soil contamination by volatile organic compounds in environmental assessments of gasoline stations.* [51]. Also Soveri, 1975, [63] has studied the hydro-geological behaviour of oil products in soil and water.

While relevant to the present study, the research focus of these abovementioned theses is different to the one adopted here. They deal with the situation when contamination has already taken place and the harmful fuel compounds have already found their way into the air, soil and water. Both researchers evaluate situations in which cleaning must be undertaken.

Another Finnish study with a bearing on the present subject is the master's thesis of the author, 2003: *Pavements of Petrol stations.* [46]. This deals with environmental protection of the pavements (asphalt, concrete, cast concrete bricks) of forecourts and fuel filling areas.

There are, in contrast, numerous international studies which deal with the topic of soil, air and water contamination at petrol station sites. However, it has not been possible to find any scientific research which specifically investigates the measures that might be taken in order to prevent such pollution in the first place. Concerning oil-retaining pervious pavements, Newman et al. [45] have studied groundwater protection. According to this study, a factitious compaction structure can effectively contain very large hydrocarbon spills.

Among the many international institutes and organizations, which have done research in the field, the following publications are the most significant for the present study. The first is entitled *Guide for assessing and remediating petroleum hydrocarbons in soils*, published in 1993 by the American Petroleum Institute [23]. The other study is the *Standard guide for risk-based corrective action applied at petroleum release sites*, published in 1995 by the American Society for Testing and Materials [64].

There is also a publication, providing much practical and technical information on the subject called the *Guidance for the Design, Construction, Modification and Maintenance of Petrol Filling Stations,* published jointly by The Association for Petroleum and Explosives Administration (APEA) and The Institute of Petroleum (IP) [24]. This includes many useful guidelines and much valuable technical information on petrol station construction.

This somewhat limited range of publications clearly suggests that, from an environmental perspective, much more research is needed in the quest for better preventative solutions to the problem of contamination at petrol station sites.

1.8 International organizations and institutes

There are, however, other sources of information and within the Oil Industry there are several major international organizations and institutes. The most important are:

- American Petroleum Institute (API),
- The Association for Petroleum and Explosives Administration (APEA),
- The Institute of Petroleum (IP),
- The International Petroleum Exchange (IPE) and
- Petroleum Equipment Directory (PEI).

These organizations and institutes mainly serve the interests of their member companies in the oil industry. They publish extensively in the field and carry out various studies and produce a wide range of materials such as guidelines and manuals suited to the special needs of the oil companies. They also organize training courses and use their expertise to provide specialized information services to their members and potential customers.

There are rather few Finnish companies with membership of these international organizations and institutes. APEA has only three Finnish members and PEI has two. It also seems likely that the two members of PEI are also APEA members, which suggests that there are actually only three Finnish companies with any membership of these international organizations and institutes. However, it is difficult to obtain information on the precise details of membership because not all organisations make this publicly available.

Unlike the international organisations mentioned above, there are also organisations whose activities are non-commercially motivated. The following organisations operate for the benefit of national and international interests:

- Coordinating European Council for the Development of Performance Test for Lubricants and Engine Fuels (CEC)

- The Oil Companies European Organisation for Environment, Health and Safety (CONCAVE)

- European Petroleum Technical Co-operation (EPTC)

- European Fuel Association (EURO-FUEL)

- European Petroleum Industry Association (EUROPIA)

- World Petroleum Congress

Membership of the above organizations is made up of various national institutes which collaborate to form these international associations. *Finnish Oil and Gas Federation* is a member of all these organizations and, for example, from Sweden, the corresponding member is *The Swedish Petroleum Institute SPI*.

1.9 Oil Industry initiatives for developing the environment in Finland

In Finland the oil industry is operated mainly by the Finnish Oil and Gas Federation. This organisation has done much to promote and develop environment protection, not only in Finland but also internationally through various joint ventures. The following are some examples of the Federation’s involvement in international co-operation [65]:

- Auto-Oil-programme (quality of fuels, sulphur-free products),

- Clean Air for Europe – programme,

- EU’s release exchange – programme,

- EU’s REACH-programme (chemical regulations),

- Initiative continuous product development and

- Active role for guaranteeing safety for sea transportation.

There are also numerous national development projects such as the following [65]:

- Waste water - programme (created in 1970s),

- Vapour recovery – programme,

- Development of safety programme in oil supplies,

- Tanker 2010 – project,

- Technological regulations for petrol stations (SFS 3352, 4. edition as reference document of BAT),

- “Höylä II” – programme, saving energy in oil heated buildings,

- Cisteri-programme, risk assessment for storage of heating oil and

- Soili programme, remediation of contaminated petrol stations.

However, despite much initiative within the oil industry in Finland, it seems that this is insufficient when considering the figures presented in Section 1.3. However, in terms of good intentions the situation is much more promising. Goodwill is vital. Know-how on its own cannot achieve the desired environmental results.

1.10. Major sources of release at petrol stations to the environment

To some degree all petrol stations release pollutants which pass into the air, soil and water.

1.10.1 To air

Petrol vapour is released into the air during the filling of storage tanks by tanker delivery personnel and when customers refuel their vehicles.

The release of petrol vapours into the air can be prevented by means of vapour recovery stage 1- and stage 2-systems. The mode of operation of these vapour recovery systems is presented in Figures 1.7 and 1.8.

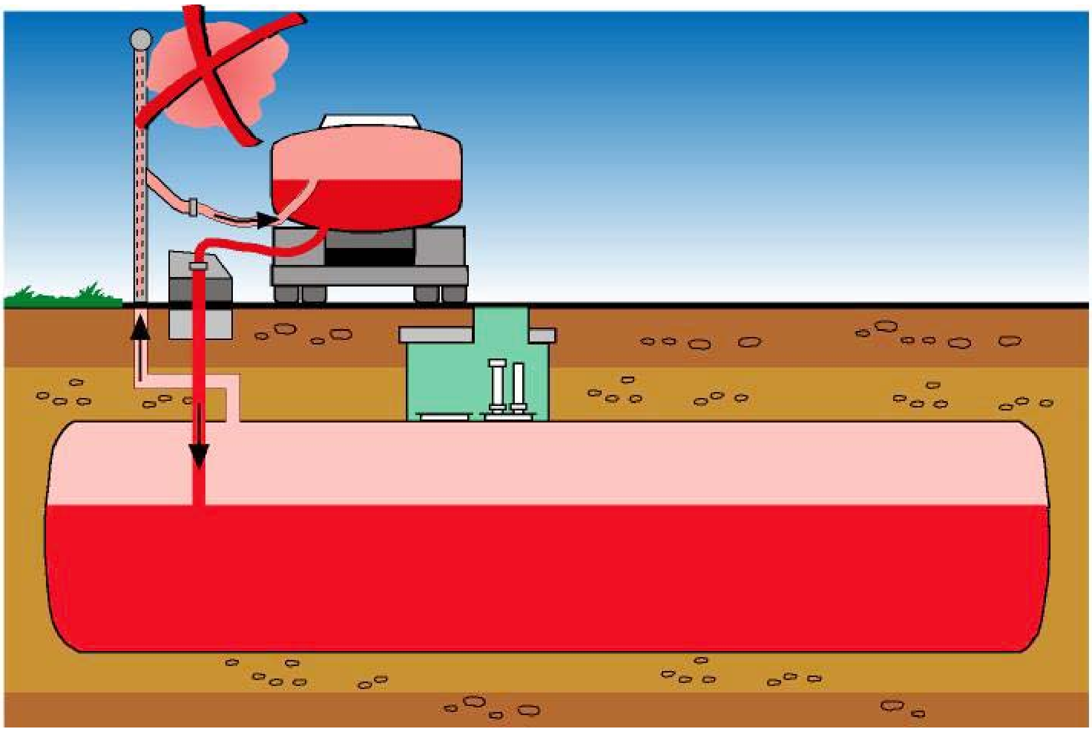


Fig. 1.7. The scheme of vapour recovery stage 1-system.

As Figure 1.7 shows, the vapour recovery stage 1-system is the process in which vapour is collected and returned to a tanker when the fuel storage tanks are being filled. The process ensures that petrol vapour is not released to the air. This is not only beneficial for the environment but also for the tanker driver who can thus avoid breathing in the toxic fumes. In addition, the risk of explosion is greatly reduced.

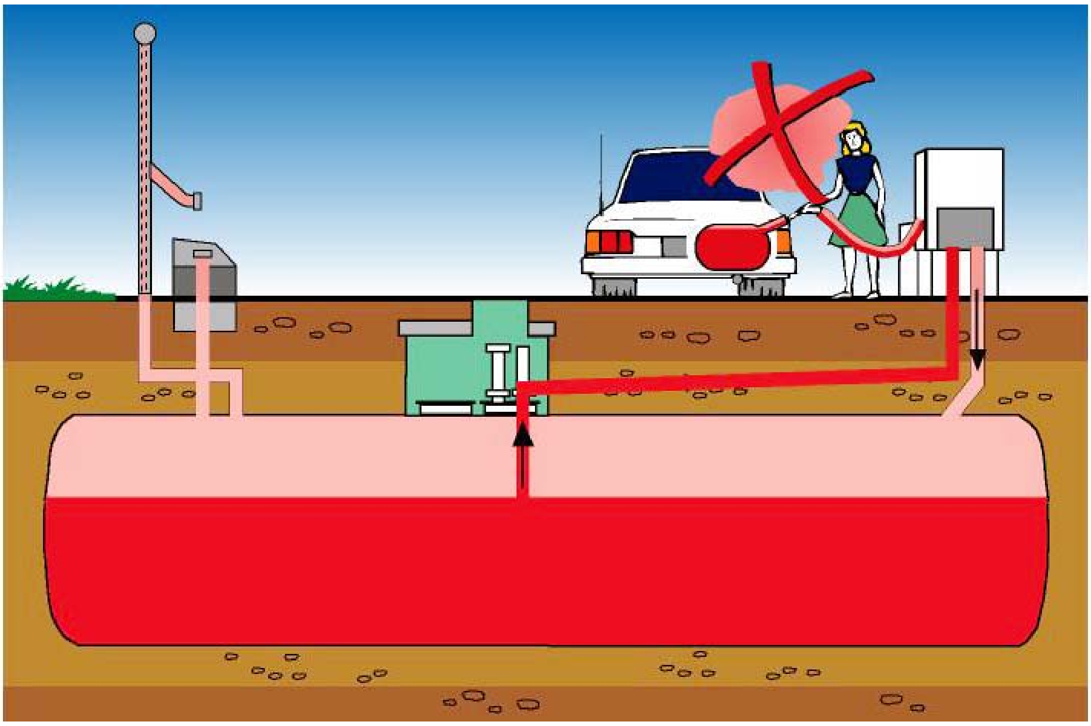


Fig. 1.8. Illustration of vapour recovery stage 2-system.

The vapour recovery stage 2-system shown in Figure 1.8 is the process in which vapour is collected and returned to a storage tank during refuelling of the customer's vehicle. The process prevents vapour from entering the air. Again, not only does this system benefit the environment but it also protects the health of customers by removing hazardous fumes. As with the stage-1, system the risk of explosion is minimized.

1.10.2 To soil

Every petrol station has the potential for releasing polluting agents into the soil. There are many possible causes for the release of these agents; the following being the most common:

- Wall of underground tank is broken.
- Underground pipes leak.
- Dispenser is leaking or broken.
- Overfill when tanker is filling storage tanks.

- Overfill when customer is refuelling the vehicle.
- Pavement of fuel filling area or forecourt is not oil-proof.
- There is no drainage and no oil separator at the fuel filling area or forecourt.
- General damage to fuel equipment and facilities.

1.10.3 To water

The release sources of pollutants into water are similar to those sources into soil. Nevertheless, removing pollutants from water has been shown to be a more costly and difficult process.

The polluting agents are easily dispersed when rainwater washes into the soil and harmful compounds, especially VOC-compounds and BTEX-compounds, are borne in the water, sometimes over great distances to reach major groundwater areas. Because of capillary action, gravity and adsorption, VOC-compounds penetrate downwards into the ground water. The most harmful chemicals are MTBE and TAME which dissolve in water.

Where a petrol station is situated in a major groundwater area, the groundwater itself can be the source for distributing the fuel compounds. In planning and implementing environment protection safeguards to prevent fuel agents entering a water system, all possible technical solutions need to be considered.

The following are some of the most important:

- 2-wall storage tanks.
- 2-wall piping.
- Oil-proof pavements.
- Drainage and oil separators.
- Factitious compaction structures.
- Real time alarm system.

Implementing the right technical solutions makes it possible to adopt a wide variety of measures to prevent fuel passing into the soil and water. These solutions are discussed in Chapter 6.

1.11. Actual situation in Finland

Different regulations are applied and interpreted in various ways depending on the parties within the Finnish Oil Industry. The authorities operate at different levels and the hierarchy of authorities and regulations is not well understood by all the parties involved. [25, 29, 30, 31, 32, 51]

In Finland the authorities that monitor the environmental aspects of petrol station activities operate at the levels of state, region and municipality. The state enacts legislation and issues the specific regulations. The regional and municipal authorities are responsible for administering permit applications and monitoring those operations at petrol stations which are relevant to environmental protection.

In terms of their areas of operation, it is possible to classify the authorities as follows; ***environmental protection authorities***, ***building officials*** and ***rescue and chemical authorities***. These bodies are controlled separately at the state level via the regional level down to the municipal level.

Under the Finnish regulatory system each authority has its own clearly defined responsibilities. The environmental protection authorities are bound by the Environmental Protection Act [12] and Environment Protection Decree [13], building officials by the Land Use and Building Act [42] and Land Use and Building Decree [43], while the rescue and chemical authorities are bound by the Chemicals Act [5] and Chemicals Degree [6] and also the decisions and decrees concerning dangerous and flammable liquids [8, 9, 10, 21]. In the light of this, it can be concluded that the Finnish regulation system is decentralized in each level at which it operates.

Differences of opinion and lack of mutual understanding between the various parties have sometimes given rise to problems at the design and construction stages. It is known that on several occasions the oil company, the designer, the contractor and the authorities have each interpreted a specific case in a different way. Such incompatibility can only undermine project success.

Nowadays there are numerous organisations issuing a multiplicity of regulations covering petrol stations. It is, therefore, hardly surprising that so much confusion exists among the parties involved as to the number of these regulatory authorities and the importance of their regulations. [4, 25, 53] There is further discussion on the subjects of bureaucracy, regulations, permits and authorities in Chapter 6.

1.12. Significance of European Union in Finland

In Finland it is commonly assumed that the European Union plays a significant and influential role in the activities of the oil industry [29, 30, 31, 32]. However, on investigation, this is clearly not the case. To date, the EU has issued only two directives relating to petrol stations, with one additional directive currently at the proposal stage. [15, 20,]

More detailed discussion of EU-directives and other regulations is to be found in Section 5.3 along with a compilation of the results of laws, legislations, statutes and other regulations affecting petrol stations.

1.13. Purpose of the study

The initiative for this study has come from private companies within the Finnish oil industry. These companies operate not only in Finland but also in the Baltic countries (such as Estonia, Latvia and Lithuania), Poland and Russia. In the future there may be plans to operate in other EU-countries as well, especially because of new membership since May 1st, 2004. The EU will offer increased market opportunities creating a vast domestic sales region with no customs borders for people or goods.

It is hoped that the outcome of this study will also be of benefit to all other participants who operate in the oil industry such as the ***regulatory authorities*** and the ***oil companies***. As a pioneer in its field, this work is expected to provide the impetus for further research in the increasingly important area of environment protection at petrol stations.

The following research questions formed the basis for specifying the purpose of this study:

1. How well are the objectives of the Environment Protection Act being fulfilled, especially those regulations for applying BAT in petrol station operations?

2. How effectively do the regulations and the operations of the various authorities influence the essential environmental impact?

3. What is the level of environment protection and BAT in Finland compared with the selected European countries?

4. How far can environment protection be made more effective by the oil companies themselves through the development of legislation and permit procedures and also by follow-up monitoring?

5. How accurately does risk analysis describe the essential and harmful impacts on the environment?

6. Which are the crucial factors to be included in BAT for petrol stations?

From an environmental research point of view, the petrol station provides an interesting and important area of study. It is well-known in Finland that there are literally hundreds of old contaminated petrol stations, most of which provide clear evidence of the dangers resulting from human error and operational failure. In addition, there are numerous major ground water areas in the country which have been contaminated as a result of the release of pollutants from petrol stations. [7, 20, 28, 29, 30, 31, 32, 46, 58] The major causes of this contamination are overfills and fuel spillage. However, leakage from storage tanks and other petrol station facilities and equipment also play a significant role in the overall damage caused to the environment.

An important part of this study was the collection and analysis of data relating to the environmental protection standards which exist in a number of other European states. Such information will provide a useful international dimension in understanding and improving the levels of environmental protection in Finland. It may also provide some surprising insights into Finland’s actual status in a European ranking of environmental pollution.

It is reasonable to assume that standards of environmental protection will vary from country to country. National levels of protection will be determined largely by such factors as legislation in the individual state as well as its own economic priorities. Such international comparisons will be useful not only within the fields of petrochemical pollution but may also identify novel technical solutions. A broadly based collection of data should, therefore, provide a wider range of solutions to the problems of this kind of environmental pollution.

In this study the countries selected for the collection of data were: Germany, Hungary, Lithuania, Norway, Poland, Russia, Spain, Sweden and United Kingdom. With the exception of Norway and Russia, these states are members of the European Union. Together they provide a representative cross-section of Europe countries on which to base a comparison with Finnish levels of environmental protection. Three of these countries, Norway, Russia and Sweden share a common land border with Finland.

From the researcher’s point of view this study poses a number of challenges to received wisdom. The most commonly held view by those employed in the various areas of the Finnish oil industry is that the level of environmental protection in Finland is generally higher than elsewhere in Europe. This majority view was expressed in very clear terms in a survey carried out at the Finnish Oil Branch’s Environment Days in Lahti, September 2004.

Of the 240 delegates at the Finnish Oil Industry’s Environment Days, one hundred participated in survey, which took the form of a personal interview. Each interviewee was asked the following questions:

"What is your personal opinion of environmental protection levels at petrol stations in Finland?"

The possible answers were:

A. Better than European levels generally.

B. Worse than European levels generally.

C. Similar to European levels generally.

D. Unable to say.

The results of this survey are shown in Figure 1.9 below.

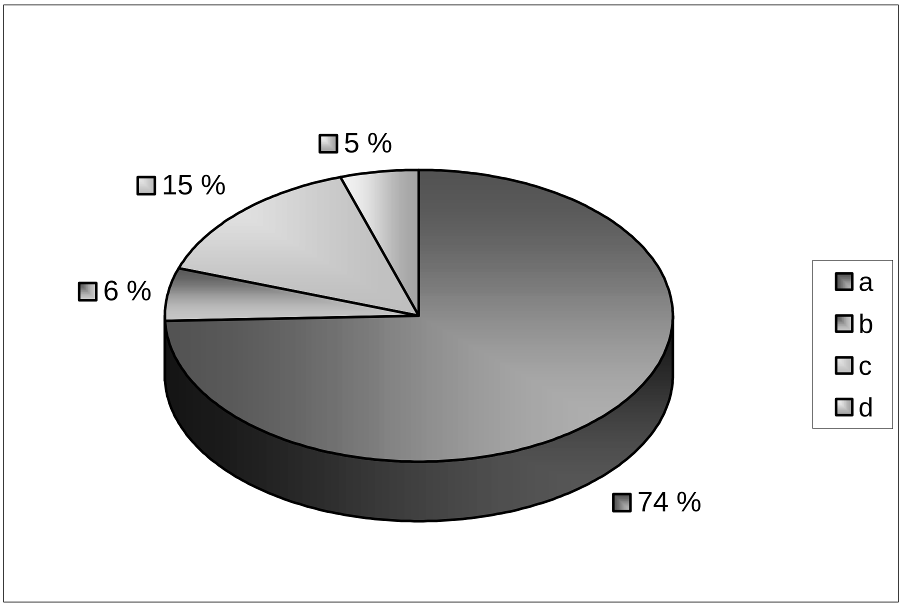


Fig. 1.9. Results of the personal interview survey conducted at the Finnish Oil Industry's Environment Days in Lahti, September 2004.

The results demonstrate unequivocally that professionals in the oil industry hold Finnish environment protection standards in very high esteem. As many as 74 % of the respondents consider Finnish environment protection levels at petrol stations to be generally better than in Europe. Of those interviewed 15 % consider the Finnish levels to be similar while only 6 % believe that Finnish levels of environmental are lower than those in Europe. Only 5 % of the respondents were unable to express an opinion.

The results of the survey suggest that prevailing beliefs in the high levels of environmental protection at petrol stations in Finland may not be easily countered without persuasive research evidence to the contrary. The majority of respondents probably also reflect the views of their counterparts in the field. It requires compelling evidence on the part of the researcher to prove that such an overwhelmingly positive view might be misplaced. The survey results, however, do at least indicate a clear majority opinion. It will be interesting to learn to what extent the results of the present study corroborate or contradict the outcome of the Lahti survey.

2. RESEARCH OBJECTIVES

The objectives of the present study are twofold. The first is to determine the levels of environmental protection at Finnish petrol stations in terms of those to be found in other countries. The other, more important, objective is to make use of the results of this study to create and promote more efficient and effective environment protection solutions.

A subsidiary objective is to investigate the administrative procedures employed by the Finnish legislative authorities in drafting and implementing the rules and regulations governing environmental protection at petrol stations.

2.1 International comparison of Finnish environmental protection standards

This objective sets out to establish the level of Finnish environmental protection at petrol stations compared with international standards. In Finland there are numerous contradictory regulations in force. From the researcher's point of view, it appears that Finland may have much to learn from other countries in this respect. Information from these international sources may provide an opportunity for improving Finnish standards of environmental protection. However, if it is shown that standards elsewhere are lower than those in Finland, it clearly makes no sense to adopt inferior practices.

2.2 More efficient environment protection

This study examines in detail the technology, risks, release sources and hazard prevention precautions required to achieve efficient environmental protection. These issues are of such obvious and vital concern to this branch of the oil industry that further justification of these objectives seems superfluous.

New information, however, is not always useful information in this or any context. From the scientific point of view, solutions discovered in other countries are not necessarily new in themselves. Despite this, solutions employed elsewhere in Europe whether new or not, may be considered innovative and of potential practical benefit in Finland.

2.3 Evaluation of legislation procedures

One of the subsidiary objectives of the present study is to determine the administrative role of legislative procedures in the oil industry. Excessive administration and paperwork can stifle initiative and development as well as hindering the successful execution of projects.

Because of the problems discussed in Section 1.11, this subsidiary objective was considered to be an essential part of the present study. After comparing the volume of administrative and legislative procedures in the selected European countries, it should be possible to obtain information which could be useful for improving Finnish procedures.

3. MATERIALS AND METHODS

3.1 Basic scientific and philosophical premises

The point of departure in this study is technology and the research itself is based on the principles of empirical inquiry. From a scientific philosophical standpoint, logical empiricism underlies the way in which the research is carried out. This means that the research principles are based on objectivity, impartiality and circumspection of the values and issues peripheral to the central subject matter. [26, 35]

Methods and materials, results and conclusions will all be presented systematically; this being one of the distinctive features of scientific enquiry [62]. Propositions and observations will be backed up by reasoned supporting evidence.

Central to the present study is the Aristotelian notion *"Argumentum Ad Hominem"*. Essentially, this involves providing the evidence and argumentation to ensure the highest probability of acceptance by "sensible and conscientious" individuals as to the veracity of an author's claims. [49]

Reproducibility of research results gained by others in the field is one of the cornerstones of scientific enquiry. A repetition of experimental procedures should lead to a repetition of results, irrespective of the individual researcher. Such principles are essential to achieve acceptance and credibility in the wider scientific community.

The research area, Engineering Geology and especially the branch of Environmental Geology, encompasses all the basic elements of Environmental Geology, namely air, soil and water. An important objective of this study is to investigate the best possible ways to prevent release sources diffusing into air, soil and water.

Systematic research involves analysis and achieves its results using methods that have been accepted and approved by the scientific community. The validity of research is tested according to logical principles, which are fundamental to reasoned argumentation. The quality of objectivity is also a vital component in lending credibility to the researcher's findings. Objectivity involves the suppression of the researcher's personal opinion, bias and wishful thinking. The researcher's own feelings and preconceptions should not be allowed to influence the results of the study. In addition to describing the results, the researcher must also explain the phenomena under investigation. The litmus test of all scientific research is reproducibility, which means the researcher must ensure that results are expressed and reported well enough in order that others in the scientific community can repeat them. [62]

3.2 Materials of the study

The original research material available at the start of this study consisted mainly of data relating to existing Finnish regulations such as laws, statutes, official decisions, standards and relevant legislation. These regulations are discussed in greater detail in Section 5.3. A substantial part of this material is to be found in the Finnish Oil and Gas Federation's Yearbooks [20], which have been published annually since 1977.

In addition to the above, it was also found necessary in the present study to create "tailor-made" sources which involved devising the following materials for data collection:

- Risk Assessment of the Major Environmental Risks and Release Sources at Petrol Stations to Air, Soil and Water (Appendix 1).
- Sampling Research Questionnaire (Appendix 2).
- Questionnaire Responses from Each of the Selected European Countries (Appendix 3).
- Field Investigation Checklist (Appendix 4).
- Results of the Practical Field Investigation (Appendix 5).

The materials are interrelated; those, which have been prepared at different stages, are linked so that earlier sources support subsequent data collection. Other data sources used in the study include personal interviews, telephone discussions and e-mail correspondence. Throughout the research period there was also frequent participation in seminars, and numerous visits to exhibitions and fairs.

A possible alternative to selected research materials and methods could be an investigation of the amount of the releases. It is common that the levels of environment protection between various countries are compared on the basis of the amount of releases. In this context, however, this would be awkward to handle. Even if it was possible to use the standards for measuring the releases, the measuring methods themselves vary from country to country. Such an alternative method would be more difficult to adopt and more less reliable than the materials and methods which were selected in this study As a result, a combination of survey and observation was selected. Together these two elements form the basis of hermeneutic research, the traditional approach of science.

Personal experience reporting has been a topic of discussion in previous doctoral theses [39, 66]. The significance of personal experience and knowledge has also been discussed extensively in the scientific literature. Personal knowledge, often referred to as “everyday thinking”, has also been described in various references as knowledge of facts, values, norms, generalizing, individual cases, perceptions, experience of life, different literary materials or researched knowledge. In “everyday thinking” the essential references are rules, mental ideas, shapes, interpretations, beliefs, experiences, thoughts and attitudes. [36, 39, 54]

It might be concluded from the above that personal knowledge encompasses a broader range of facts than researched knowledge. However, it is also true that the contents of personal knowledge are typically less precise and consistent. [50, 54, 68]

“Everyday thinking” is a preliminary stage in understanding reality. It complements scientific knowledge and can enrich it by injecting commonsense into any counter-intuitive outcomes following on from scientific scrutiny. Moreover, rigid application of the scientific method can sometimes also undermine innovative thinking and the discovery of novel solutions. [50, 68]

3.2.1 Risk analysis and major release sources

The first stage in the preparation of materials involved the identification of risks and release sources. This necessitated a thorough examination of a wealth of documentary sources such as requests for and the issuance of permits, as well as the relevant documents containing the rules and regulations in force. In addition, personal interviews were conducted and personal experience and knowledge also contributed to the collection of data. The risks and release sources identified in the study are well-known among the oil industry fraternity and there has been considerable discussion of the issues involved. Despite the widespread concern in the industry about environmental protection issues, there has so far been no attempt to systematically collect and document the risks and release sources.

Reference methods for applying the risk analysis theory

Risk analysis is based on the general theories and methods employed in safety engineering. As mentioned in Section 1.6, the subject of environmental risk theory covers a wide range of issues. This study employs the standard methods contained in *Dependability Management. Part 3: Application Guide. Section 9: Risk analysis of technological systems SFS-IEC 60300-3-9 [11]* and *Risk Analysis for Accidental Releases – SARA [69]*.

The standard [11] presents the important terminology and sets out the procedure for implementing not only the theoretical principles but also for the practical application of risk assessment. According to these standards the three fundamental questions to be asked and answered by means of the principles contained in parentheses are as follows:

- What can go wrong (by hazard identification)?
- How likely is this to happen (by frequency analysis)?
- What are the consequences (by consequence analysis)?

According to the standard [11], before risk can be effectively managed it should be analysed. The analysis of risk is a useful tool for;

- identifying risks and approaches to their solution

- providing objective information for decision-making

- fulfilling the regulatory requirements.

The above are the key elements linking risk theory to the present study. The standard also includes risk categorization. Risk can be divided into four general categories; natural, technological, social and lifestyle hazards. Risk can also be categorized according to the nature of the consequences that are being investigated. One of these categories is environmental; impact on air, soil and water.

The risk analysis process according to standard [11] consists of the following phases:

- Hazard identification and initial consequence evaluation
- Risk estimation
- Analysis verification
- Documentation
- Analysis update

In the present study the standard [11] was useful in providing the basic information on the theory of risk analysis. Another practical and useful source here is Risk Analysis for Accidental Releases – SARA [69]. This contains a method for the identification and assessment of potential accidental releases to the environment from industrial processes. It can be applied in the process industry and in other kinds of enterprise. It is also a suitable method for use in small and medium size organizations. SARA’s risk analysis procedure is presented in Figure 3.1.

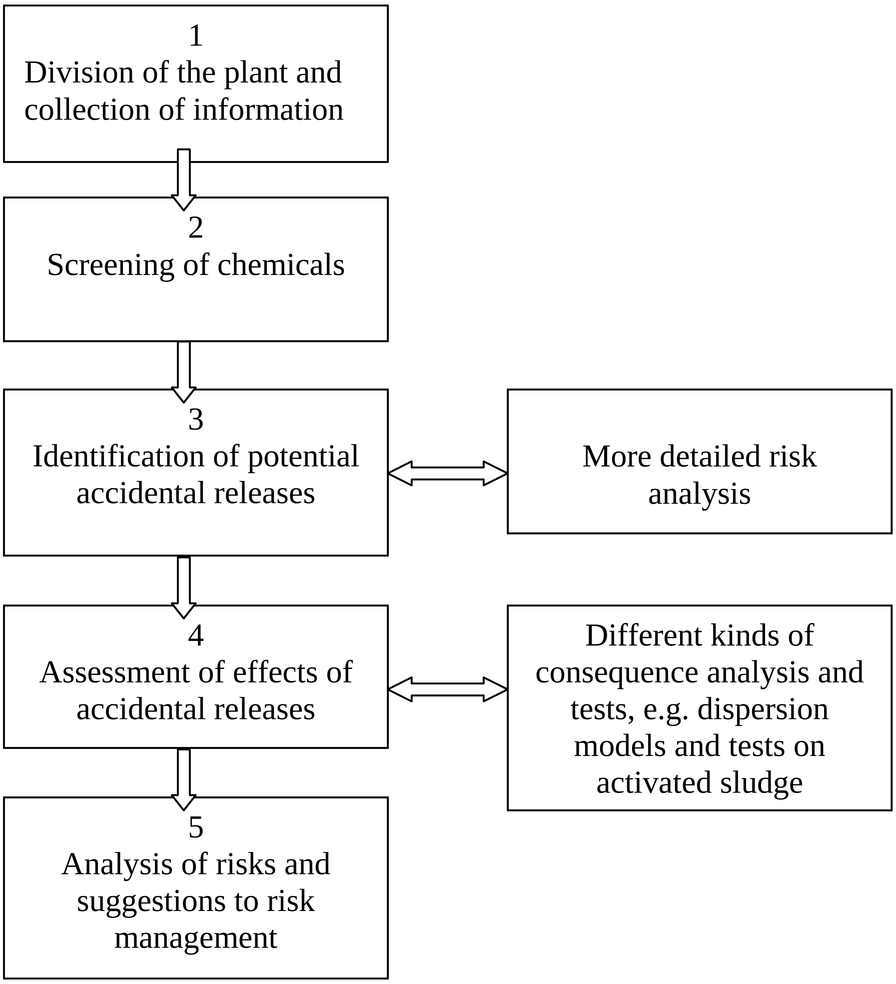


Fig. 3.1.Risk analysis procedure according to SARA.

<u>Methods selected for the application of risk analysis</u>

On the basis of the above-mentioned sources and for the purposes of the present study, it was decided that the most appropriate form of risk assessment for the oil industry should involve the following phases:

- Definition of risk.
- Definition of risk probability.
- Definition of risk significance.
- Risk evaluation (size of risk = probability * significance).
- Specification of the risk level.

First, the risk factor was identified and the release source was described. After this, the risk probability and its significance were evaluated. At this stage it is sometimes possible to determine the risk level and discover ways and means to prevent potential accidents. The degree of risk is described in terms of the following scale: insignificant, tolerable, moderate, remarkable and unbearable risk.

It was not considered necessary in the present study to focus on risk probability and significance which is normally dependent on local conditions. It was considered important to identify the risk and release sources for two reasons: to pinpoint the problems found at petrol stations and to help in devising the questionnaire.

All the identified risks and release sources are presented in Appendix 1. As stated above, the risk list helped in drawing up the questionnaire and underlies the systematic and logical principles employed here.

3.2.2 Questionnaire

The questionnaire was prepared for the collection of the factual information. Wherever possible, the questions were devised to elicit a straightforward “yes” or “no” response in order to eliminate ambiguity and to minimise the need for speculation in the analysis of the data.

In compiling the questions, note was taken of both the theoretical background and the need to educe answers that were descriptive of the phenomenon. Before distributing the questionnaires to the respondents, a pilot study interview was conducted on a small sample group. On the basis of the results of the pilot study, modifications were made to the questionnaire before it was eventually sent to the respondents. The questionnaire was sent to 4-6 professional informants in each of the selected countries.

The questionnaire, which constituted one of the main tools in this study, is presented in Appendix 2.

3.2.3 Questionnaire responses

Answers to the questionnaire were received from 3-5 respondents in each country. These replies were not treated as actual results but rather as a useful tool to help in analysing and assembling the final results. They are presented in Appendix 3 and also in greater detail within the text, in the context of the environmental protection topic being considered, along with other the results in Chapter 5.

The statistical distribution of responses to the questionnaires by country is presented in Table 3.1.

Table 3.1. Statistical distribution of questionnaires and received response by country.

Country	Sent questionnaires	Received questionnaires
Finland	*	*
Germany	5	3
Hungary	5	3
Lithuania	4	4
Norway	5	3
Poland	6	4
Russia	4	3
Sweden	6	5
Spain	4	3
United Kingdom	5	4
Total	44	32

* The questionnaire was not distributed in Finland. Planning of the questionnaire was undertaken in consultation with a number of Finnish professionals. The answers were obtained by this researcher and subsequently verified in collaboration with senior Finnish oil industry personnel.

3.2.4 Check list for the practical field investigation

The checklist and the practical field investigation were carried out to verify the answers received from the various international respondents. Though the present study is based mainly on theoretical information, it was also felt necessary to conduct practical field checks at petrol stations in each selected country. This made it possible to verity the responses and ensure that the individual petrol stations met the appropriate regulations in force.

During the practical field study it was not possible to verify all the responses to the questionnaires. It was, for example, impossible to examine underground installations and so field investigations were confined to surface facilities. Despite these limitations, practical field investigations proved to be both necessary and useful in validating the responses to the questionnaires.

A completed sample checklist of one of the petrol stations is presented in Appendix 4. Practical field investigations were carried out at a total of 977 petrol stations, which proved to be a major undertaking in itself. Petrol station investigations by country are shown in Table 3.2. A more specific summary of the stations visited and oil company ownership is presented in Appendix 5.

Table 3.2. Investigated petrol stations by country.

Country	Inspected petrol stations
Finland	409
Germany	37
Hungary	59
Lithuania	68
Norway	62
Poland	74
Russia	50
Sweden	92
Spain	62
United Kingdom	64
Total	977

3.3 Methods of the study

3.3.1 Scientific overview of methods

In attempting to explain and predict the world around us, research in the empirical sciences adopts two main approaches. The first of these approaches seeks to discover facts through evidence while the second seeks to formulate theories and hypotheses. These two approaches correspond respectively to the two main traditions of scientific thinking, namely ***positivism*** and ***hermeneutics***. In terms of the history of science these two schools of thought can also be distinguished according to the conditions an explanation must fulfil for it to be considered scientifically respectable. The distinction between these two approaches has been expressed by the German philosopher Juhan Gustav Droysen in terms of a dichotomy between “understanding” and “explanation”. A positivistic research approach will focus on regularities and natural laws whereas a hermeneutic research approach seeks to explain the phenomenon that falls within its domain. [33]

The adoption of either of the above approaches also has an important bearing on whether a particular scientific study is to be conducted quantitatively or qualitatively.

Quantitative research is based on a positivistic approach and seeks to study phenomena and collected data in terms of quantifiable entities or measurable units. Typically, variable quantities are handled mathematically and statistically in order to achieve the reliability and objectivity of the results.

Qualitative research is, from a philosophical point of view, hermeneutic. Commonly adopted in the social sciences, this type of research typically draws on models such as case studies in order to elucidate an understanding of more general principles. The focus of qualitative research is more often directed to the significance of phenomena. [2, 47, 62]

The theoretical framework of reference will determine the kind of method(s) to be applied in the collection of the research material. For the purposes of the present study a qualitative approach was considered to be the best suited. [2]

3.3.2 Qualitative research

Evidence is the raw material of scientific research. When the environment is the subject of investigation, empirical data are collected in various ways by such means as be following [62]:

- observation
- interviews
- surveys
- proxemics and kinesics
- artefacts and documentation
- projective techniques.

In the present study, the first three of the above methods of data collection were deemed the most suitable. By personal *observation* it is possible to obtain information immediately and directly associated with the phenomena being studied. *Interviewing* is the interaction between the interviewer and interviewee to gain information based on personal experience and knowledge with the aim of gaining valid and reliable information. The interview is an effective way of acquiring a large amount of information within a short period of time. *Surveys* have commonly been used in quantitative research but they are also well-suited to qualitative research. [62]

The research progression followed in the present study is presented in the flow chart shown in Figure 3.2. It should be noted here that that the flow chart also contains the major stages that form the basis of scientific research as presented in, for example, Niiniluoto [47].

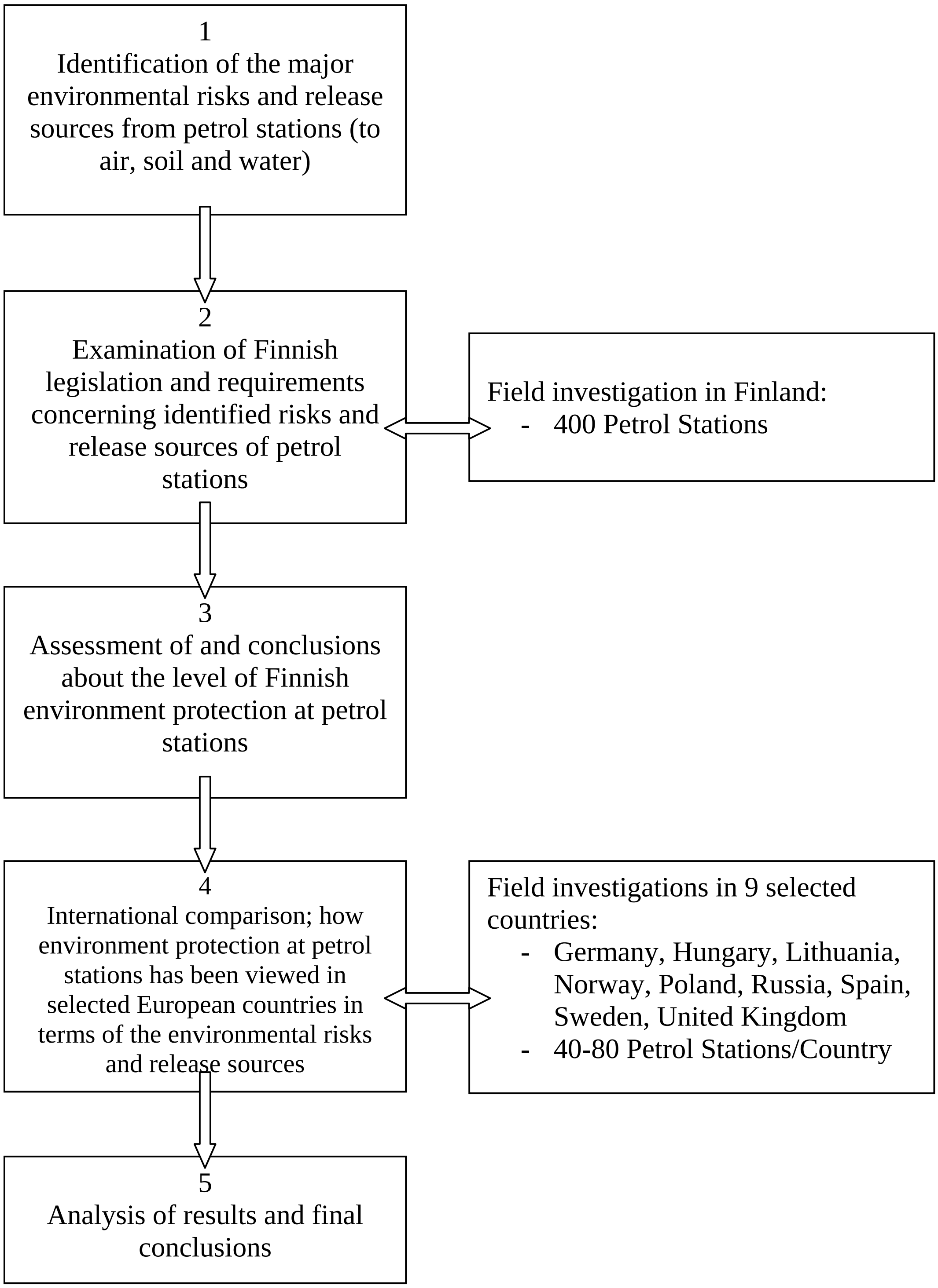


Fig.3.2. Flow chart describing progression of research in the present study.

The first part of this study is based mainly on research into the situation in Finland. It starts with a review of the technology and facilities to be found at petrol stations throughout the country and then investigates the major environmental risks and release sources from petrol stations to air, soil and water. There is also an examination of the relevant Finnish legislation and regulations relating to the risks and release sources identified at petrol stations.

The second part of this study considers the international dimension of the subject. The data here was collected on the basis of extensive research and involved numerous interviews with professionals in the field in each selected country. The study also includes a practical field investigation in Finland and in selected European countries. In order to obtain a representative data sample, a total of 977 petrol stations were visited both in Finland and in the selected European countries.

3.3.3 Sampling research

Scientific background of sampling research

In the present study the main method employed for obtaining data is sampling research. The target population of this study were oil industry professionals based in the nine European countries selected.

The two main types of sampling are known as ***probability sampling*** and ***non-probability sampling***. The latter contains a number of sub types, which include the following: [62]

- purposive sampling/judgement sampling
- quota sampling
- convenience sampling (accidental sampling)
- dimensional sampling
- snowball sampling.

The sampling technique deemed most suitable for the purpose of the present study was a combination of purposive/judgement sampling, quota sampling and convenience sampling.

Sampling research has been shown to improve the quality of research compared to that achieved by the examination of an entire population. In sampling research the questions to be addressed are considered more thoroughly, while false or dubious information will be easier to recognise. Processing the information obtained will also be more straightforward. [1]

Sample size

The size of the sample depends on the research objectives and the kind of analyses to be undertaken. The greater the number of subjects to be investigated in a scientific study, the greater should be the size of the sample. [67]

Determining sample size is one of the critical factors in the entire research process. According to Soininen, the criteria to be considered are: The research objectives, the analysis, the population's heterogeneity/homogeneity in relation to the researched phenomena, the number of categories being studied and the resources of the researcher. The more specific the data, the bigger the sample should be. Again, when numerous issues are under investigation, there will be a need for a larger sample. Size of sample is also dependent on the inherent population mix; a homogeneous population normally requiring a smaller sample while a heterogeneous population will normally call for a bigger one. [62]

In general, quantitative research normally involves bigger samples than qualitative research. [62] In practice, however, the size of sample will often be determined by the constraints of time, money and human resources [34].

In this study, the sample size was considered to be reasonable and manageable. According to this researcher's knowledge of the oil industry in each of the selected countries, there are only a limited number of professionals who are fully conversant with national regulations and the relevant technology. In each country there are only a handful of professionals in oil companies who hire the services of consultants and contractors who also serve the same oil companies. It has been estimated that in each country there are clusters of no more than 10-40 individuals with sufficient knowledge of the field to act as reliable respondents to the questionnaire. In terms of Aristotelian philosophy such individuals are refereed to as being *sensible* and *conscientious* [49].

Here, however, sample size does not correlate to size of population. It was not deemed necessary to conduct an Aristotelian Gallup poll to ensure that a decision will always be based on the opinion of majority. The objective in the present study was to find an even more reliable means of sampling in order to ensure a unanimous response. It was decided, therefore, that the sampling would be conducted with the exclusion of open questions.

The main purpose was to achieve consistently similar responses which would be proved to be true. This would be possible only if there were an equal number of answers from each country to the same question. As mentioned in Section 3.2.2, the questionnaire was sent to between 4 and 6 professionals (*sensible* and *conscientious* individuals) who were each considered to have the best knowledge of petrol stations and the oil industry in their own country. The ideal objective was that all responses should be equal, which means the maximum possible probability. Receiving questionnaire responses containing the same information from the same country is, indeed, tantamount to truth proven knowledge. Conversely, conflicting and contradictory responses from the same country strongly indicate a need to clarify procedures including confirmation of the respondent’s understanding of the questionnaire. In practice, however, it proved impossible to receive totally consistent or unanimous responses though the principle itself was deemed appropriate for the purposes of present study. An evaluation of the responses to the survey questions is presented in Section 4.2 along with the other results of this study.

3.3.4 Practical field investigation

The practical field investigation constitutes an important part of the main method; sampling research. This field study was considered as forming a subsidiary method.

It was the method used for analysing the questionnaire responses relating to environmental issues. In other words, the technical field study was a means for verifying that the answers received conformed to actual local conditions. If there is shown to be a close correspondence between responses and the actual conditions, then it follows that the responses themselves are more likely to be accurate. Conversely a wide disparity between responses and actual conditions would suggest that the responses were unreliable.

3.4 Limitations

The scope of this research is confined to what are seen as key topics. By ignoring peripheral issues it is hoped to achieve a fuller examination of the central subject matter and avoid an overly wide-ranging and superficial approach to the subject. This restricted scope also allows for more controlled research, not only with respect to materials, but also the methods and results. [50]

Limiting the scope of the research also reduces the amount of theoretical speculation which can undermine the significance of the practical findings.

Geographical limitations

The choice of Europe as the source of comparative data was based on practicalities such as time and distance. It would have been impossible to extend the research to include other continents. The European countries selected for the collection of data are together regarded as providing a representative cross-section of Europe countries on which to base a comparison with Finnish levels of environmental protection.

Types of petrol station

The study considers the standard petrol station model, which typically includes underground storage tanks, fuel equipment and piping, a forecourt and associated buildings. Petrol stations whose premises did not conform to this model were excluded from the investigation, as they were normally not subject to the common general regulations in force.

During the practical field investigation it was only possible to study those facilities and equipment where it was possible to gain access or make on-site investigation. It was not possible, for example, to go underground and the research was confined to standard petrol station models. The main types of petrol station omitted from the study were those with aboveground tanks. Petrol stations for boats, such as those to be found at marinas, were also excluded. Both of these petrol station models are relatively uncommon and they are also subject to different and more specific regulations.

Materials of equipment and structures

There is a wide range of fuel equipment and many different structures and facilities to be found on the premises of the standard petrol station. However, it is not the intention here to investigate in detail all the associated technical details when this fails to yield information relevant to the subject. For example, no comparisons will be made concerning the relative merits of the petrol pipe materials, such as steel, plastic and fibreglass, or whether oil separators should be made of steel, plastic or fibreglass. Instead, the focus of the research is on such matters as whether or not an oil separator is needed rather than the material used in its construction.

In the oil industry the issue of suitable materials is obviously a legitimate subject of interest. Indeed, a comparison of the various construction materials used in petrol station projects would in itself provide a fruitful topic for separate research.

Regulations in selected countries

First hand investigation and examination of all the various national regulations such as laws, statutes and other forms of legislation was clearly an impossible objective due to the vast quantity of data involved. Because of this, a system was developed for obtaining this regulatory and legal data from specialist informants from each of the selected countries.

4. RELIABILITY OF RESULTS

4.1 Research objective

The research objective will be evaluated partly on the basis of the theory of attitudes presented in Lincoln & Cuba, 1985 [44] for examining reliability in qualitative research. Instead of the term ***reliability*** the authors have recommended the use of the term ***trustworthiness***. Implicit in the term are four questions the researcher should ask:

1. **Truth-value** – How would it be possible to achieve reliability of the research results?

2. **Applicability –** How applicable are the results to another array or group?

3. **Consistency** – How it is possible to be certain that the results would be the same if the research is repeated under similar circumstances?

4. **Neutrality** – How certain is it that the results are based on the respondent's actual circumstances and not distorted by the researcher's own motives or interests?

Lincoln and Cuba, 1985 [44] also recommend the use of the terms *credibility*, *transferability*, *dependability* and *conformability*. In this study these terms have been understood as follows: Credibility means that reconstructions are the same both in research and in practice. Results are considered to be transferable when they can be applied in similar situations within the context of petrol stations. Not only the results, but also the entire research has been subject to tests of dependability, which it is believed has been demonstrated. Transferring objectivity from one researcher to another guarantees the objectivity of the results. Lincoln and Cuba, 1985 [44] refer to this quality using the term *conformability.*

In evaluating the present researcher's objectivity, the following can be stated:

- results are based on professional respondents

- the researcher’s personal opinions have not consciously influenced the results of the interviews

- the materials and methods employed have been appropriate to their use

- there is sufficient evidence to prove the results

- all comparisons have been made on the basis of the results.

4.2 Validity of selected material and methods

According to Uusitalo, 1995 [67] *validity* corresponds to a gauge’s ability to measure accurately that for which it was designed to measure. When the theoretical and practical definitions are identical, validity is deemed to have been proved. In principle, measuring validity is essentially straightforward: the results should be compared with actual experience. In practice, however, real knowledge does not always exist.

Every attempt has been made in this study to identify all the important and essential elements in the planning and selection of the material and methods. It is, of course, possible that an item has been overlooked but this will not, in itself, undermine the foundation of knowledge on which the results of this research rest.

The most significant aspect of the results has been the responses to the questionnaires. Initially, disparity between certain responses was noted and this led to their removal at the analysis stage. On the other hand, it is also a result that some dispersion did exist. This indicates that not all the issues investigated were totally clear and that not all the professionals involved fully comprehended the actual conditions prevailing in their respective countries. This suggests that there are problematic issues in the oil industry, not only in Finland but also elsewhere.

When comparing the ***Questionnaire*** with the ***Practical Field Investigation***, it is clear that the Questionnaire, or more specifically the ***Questionnaire responses,*** is more important from a research point of view. The results are more a reflection of the questionnaire responses than the field investigation. However, the practical field investigation played an important practical role in the study as it clarified and confirmed actual conditions on the ground. In a number of countries it was evident that not all the requirements in force had been met, while in the majority of the selected countries it was also clear that the rules and regulations were not always observed in full.

From the researcher's point of view the materials and methods selected were both appropriate to their use and feasible to implement. An alternative method to selected ***Sampling research*** would have involved the researcher in undertaking a study of the legislation in force in each of the selected countries. This would have been unnecessarily burdensome or even impossible to do single-handed.

5. RESULTS

The major results of this study are composed of three main parts: s**urvey, observation** and **examination** of the administration, legislation, and regulations governing environmental protection at petrol stations, together with their associated problems and permission granting procedures. This Chapter also presents additional results in Section 5.5.

5.1 Results of the survey

The present Section contains a major part of the significant information in this study for making possible an assessment of the level of environment protection at Finnish petrol stations. The assessment is made on the basis of the three main elements of environmental protection; **air**, **water** and **soil.**

The results are all based on responses to the questionnaire which are contained in Appendix 3. Colour coding is used in presenting the responses in order to facilitate their interpretation. Green is used to represent environmental friendliness, whereas red represents the very opposite state, i.e. environmentally hostile. Light blue indicates that the responses have little environmental significance or that the issue has not been adequately addressed in the response. Grey indicates that no response has been received. Finally, in some of the results tables no colour coding has been used and the figures are shown in black on white.

Numbering of the questions follows the sequence used in the questionnaire. After sending the questionnaire to the respondents, it was considered more appropriate to process the questions according to the particular topic being studied such as air, soil and water. However, the need to retain the original ordering of the questionnaire is the reason they are presented this way.

5.1.1 Air protection

The results relating to the subject of air protection are based on vapour recovery systems. Information on the national requirements concerning vapour recovery was obtained from responses to questions 25 and 26 which are as follows:

> Question 25
> *Is it required under your country's legislation to equip petrol stations with a vapour recovery stage 1-system?*
>
> Question 26
> *Is it required under your country's legislation to equip petrol stations with a vapour recovery stage 2-system?*

The answers are shown in Table 5.1.

Table 5.1. Answers to questions 25 and 26.

Answer	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
25	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
26	NO	YES	YES	YES	NO	YES	YES	NO	YES	NO

As Table 5.1 shows, petrol stations in all of the selected countries were required to have vapour recovery stage 1-system equipment. A vapour recovery stage 2-system is not required in Finland, Norway, Spain and United Kingdom.

In theory, based on these regulations, it would be easy to conclude that the air protection level in Finland is lower than in the other selected countries, with the exception of Norway, Spain and United Kingdom.

5.1.2 Soil protection

In this study different means are used for evaluating soil protection levels. These are classified according to the following areas:

- pavement materials
- drainage of forecourt and fuel filling areas
- 1-wall or 2-wall storage tanks
- 1-wall or 2-wall piping
- inspection and operating procedures
- miscellaneous equipment.

Pavements

Pavement materials are evaluated on the basis of previous studies [46] according to certain standards. Environmentally, the best pavement material is concrete followed by concrete brick (where there is a factitious compaction structure under the pavement) and finally asphalt. Other pavement materials such as gravel and grass are excluded from the present evaluation since they are considered to be totally inappropriate for use at petrol stations.

The following questions, 15 to 20, relate to pavement areas and their materials:

Question 15
Is it permitted under your country's legislation to construct forecourt pavement areas using concrete bricks?

Question 16
Is it permitted under your country's legislation to construct forecourt pavement areas using concrete?

Question 17
Is it permitted under your country's legislation to construct forecourt pavement areas using asphalt?

Question 18
Is it permitted under legislation in your country to construct the pavement of fuel filling areas using concrete bricks?

Question 19
Is it permitted under your country's legislation to construct the pavement of fuel filling areas using concrete?

Question 20
Is it permitted under your country's legislation to construct the pavement of fuel filling areas using asphalt?

Responses to the questions dealing with materials used in the pavement area are presented in Table 5.2.

Table 5.2. Answers to questions 15 to 20.

Answer	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
15	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]
16	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
17	YES	YES[14]	NO	YES[15]	YES	YES[15]	YES	NO	YES	NO
18	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	NO
19	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
20	YES	YES[14]	NO	YES[14]	YES	YES[14]	NO	NO	YES	NO

YES[13] = In each country the use of concrete bricks is permitted as a forecourt paving material. It is also a requirement in every country to use some form of oil-proof sealant.

YES[14] = Asphalt itself it not enough. If asphalt is used, it must be a certified pavement system and/or a factitious compaction structure is needed.

According to the responses to questions 15 to 20, it can be concluded on the basis of pavement type, that soil protection levels are lower in Finland than in Germany, Hungary, Lithuania, Poland, Russia, Spain and United Kingdom. Similar levels to Finland are found in Norway and Sweden.

Drainage of forecourt and fuel filling areas

Questions 11 and 12 deal with the drainage of forecourts and the fuel filling areas:

Question 11
Is it a requirement under your country's legislation to sewer rainwater from the forecourt to the oil separator?

<u>Question 12</u>
Is it a requirement under your country's legislation to sewer rainwater from the fuel filling area to the oil separator?

The answers are shown in Table 5.3 below.

Table 5.3. Responses by country to questions 11 and 12 concerning drainage systems.

Answer	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
11	YES	YES	YES	YES	YES[11]	YES	YES	YES	YES[11]	YES
12	YES	YES	YES	YES	NO	YES	YES	YES	YES[11]	YES

YES[11] = In Norway and Sweden this requirement is applicable to old stations; hence the use of red.

It should be mentioned here that in Sweden, it is only new petrol stations that are required to have drainage systems and oil separators in forecourts and fuel filling areas. In Norway a similar regulation applies to forecourts, though fuel filling areas are not required to have drainage on the fuel filling area. However, a number of the international oil companies operating in Norway follow international practice so that a number of petrol stations actually do have such systems.

<u>Single wall as opposed to double wall piping and storage tanks</u>

Questions 1, 7, and 31 deal with the subject of 1- or 2-wall storage tanks and petrol piping:

<u>Question 1</u>
Is it permitted under your country's legislation to construct a petrol station with 1-wall underground storage tanks?

<u>Question 7</u>
Is it permitted under you country's legislation to construct petrol stations having 1-wall petrol pipes (suction and filling pipes)?

<u>Question 31</u>
Is it required under your country's legislation to use 2-wall petrol pipes?

The results to this part of the questionnaire are shown in Table 5.4 below.

Table 5.4. Responses to questions 1, 7, and 31.

Answer	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
1	YES	NO	NO	YES	YES	NO	YES[1]	YES[2]	YES	NO
7	YES	NO[9]	NO[9]	YES	YES	YES	YES	YES	YES	NO[9]
31	NO	YES[21]	YES[21]	NO	NO	NO	NO	NO	NO	YES[21]

YES[1] = Only if certain additional requirements are fulfilled.

YES[2] = Yes, but only if 1-wall tanks will be installed in a concrete bunker (=2-wall).

NO[9] = In Germany, Hungary and United Kingdom filling pipes (and pressure pipes) are always required to be 2-wall.

YES[21] = In Germany, Hungary and United Kingdom filling pipes (and pressure pipes) are always required to be 2-wall.

With regard to single and double walls, the above responses clearly demonstrate that the level of environment protection in Germany, Hungary, and United Kingdom is considerably higher than in Finland. Moreover, according to the table above, Poland also appears to have a higher level than Finland, since in Finland it is permitted to install 1-wall tanks at petrol stations. In all the other countries, however, the level of environment protection is similar to that in Finland.

Inspection and control processes

Questions 2, 3, 8, 9 and 13 all deal with inspection and control processes:

Question 2
Is there any legal requirement in your country to conduct periodic inspections of 1-wall underground storage tanks?

Question 3
Is there any legal requirement in your country to conduct periodic inspections of 2-wall underground storage tanks?

Question 8
Is it a requirement under your country's legislation to conduct periodic inspections of petrol pipes?

Question 9

Is it a requirement under your country's legislation to install a monitoring well for checking the soil in the area surrounding underground tanks?

Question 13

Is there any requirement under your country's legislation to conduct periodic inspections of drainage equipment (pipes, wells, etc.)?

The answers are shown in Table 5.5 below.

Table 5.5. Answers to the questions 2, 3, 8, 9 and 13.

Answer	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
2	NO[3]	YES[4]	NO[5]	YES	YES	YES	YES	YES	YES	YES
3	NO	YES	YES	YES	NO	YES	YES	YES	YES	NO
8	NO	YES	NO	NO	NO	Y/N	YES	YES	NO	Y/N
9	NO	NO	NO	YES[10]	NO	Y/N	YES[10]	Y/N	NO	YES
13	YES[12]	YES	YES[12]	NO	NO	YES[12]	YES	YES	NO	NO

NO[3] = 1-wall tanks are only inspected if they are located in major groundwater catchment areas.

YES[4] = Only applicable to older existing tanks.

NO[5] = In Hungary 1-skin tanks should not exist at all.

YES[10] = In Lithuania and Russia only applicable to 1-wall tanks.

YES[12] = Applicable to oil separators (and other separators), but not to other drainage systems.

As the results show, environment protection levels in terms of inspection and control processes are lower in Finland than in all the other countries except Norway, where the level is somewhat similar to Finland.

Miscellaneous equipment and other issues within the category of soil protection

Questions 21, 22, 24, 27, 28, 29, 30, 32, 33, and 34 all deal with miscellaneous equipment and other issues within the category of soil protection:

Question 21
Is it required under your country's legislation to construct a factitious compaction structure (e.g. made of HDPE-membrane or bentonite) under forecourt pavements?

Question 22
Is it required under your country's legislation to construct a factitious compaction structure (e.g. made of HDPE-membrane or bentonite) under the pavement of fuel filling areas?

Question 24
Is it required under your country's legislation to equip petrol stations with an overfill prevention system?

Question 27
Is it required under your country's legislation to equip underground tanks with a chamber (sump, manhole, maintenance well)?

Question 28
Is it required under your country's legislation to ensure that an underground tank's chamber is sealed tight?

Question 29
Is it required under your country's legislation that the interface between the dispenser (bottom of dispenser or sump under the island) and the ground is sealed tight?

Question 30
Is it required under your country's legislation to equip the filling pipe with a filling sump or such device to prevent splashed fuel seeping into the ground?

Question 32
Is it required under your country's legislation to construct a factitious compaction structure (e.g. made of HDPE-membrane or bentonite) beneath and around underground petrol piping?

Question 33
Is it permitted under your country's legislation to have underground spaces (chambers, sumps, channels, etc.) beneath the forecourt (making it possible for petrol vapour to reach such areas)?

Question 34
Is it permitted under your country's legislation to have underground spaces (chambers, sumps, channels, etc.) beneath fuel filling areas (making it possible for petrol vapour to reach such areas)?

Responses to the questions are shown in Table 5.6 below.

Table 5.6. Responses to questions 21, 22, 23, 27, 28, 29, 30, 32, 33 and 34.

Answer	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
21	NO[16]	NO[17]	YES	YES	NO	YES[18]	YES	NO	NO	NO
22	NO[16]	NO[17]	YES	YES	NO	YES[18]	YES	NO	NO	NO
24	YES	YES	YES	YES	NO[19]	YES	YES	YES	YES	YES
27	YES	YES	YES	YES	NO	YES	YES	YES	NO	YES
28	NO	YES	YES	NO	NO	YES	YES	YES	YES[20]	YES
29	YES	YES	YES	NO	Y/N	YES	YES	YES	YES	YES
30	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
32	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
33	YES[22]	NO	NO	YES	YES	Y/N	NO	Y/N	NO	YES
34	YES[22]	NO	NO	YES	YES	Y/N	Y/N	Y/N	NO	YES

NO[16] = No, only if the pavement is made of concrete bricks or normal asphalt.

NO[17] = No, the pavement itself must be dense and oil-proof.

YES[18] = Yes, if this is the only way to ensure the density prevents harmful compounds seeping into the ground.

NO[19] = Not required by law in Norway but normally installed in practice.

YES[20] = Yes, if a sump is installed. In such cases it must be sealed or filled with sand or mineral wool or other such materials.

YES[22] = Only if there is ventilation.

Questions 20 and 21 deal with factitious compaction structures. Previous studies [46] show the need for a factitious compaction structure under the pavements of forecourts and fuel filling areas, irrespective of the pavement material used. The reason given for this is that even concrete is vulnerable to damage because of poor quality and/or workmanship. In addition, improper concrete curing can cause capillary cracks (i.e. hairline cracks) which can provide an exit for harmful compounds into the soil and water.

Table 5.6 shows that, in terms of these somewhat peripheral considerations, Finland appears to have higher levels of environment protection than Norway but lower than those in Germany and Hungary. In the other countries, however, levels are much the same as those in Finland.

5.1.3 Water protection

As mentioned in Section 1.10.3, the release sources of pollutants into water are similar to those into soil. It is worth noting in the present context that the factors discussed in Section 5.1.2, all have an important bearing on water protection. This Section presents some important additional issues and results.

The questionnaire results presented in Section 5.1.2 also apply to water protection and questions 5 and 6 below provide additional information on the subject as follows:

Question 5
If there are major groundwater catchment areas in your country, is it permitted to construct a petrol station in such areas?

Question 6
If an existing petrol station is located on an important groundwater catchment area, is it permitted to have single wall underground storage tanks?

Responses to these questions are presented in Table 5.7 below.

Table 5.7. Responses to questions 5 and 6.

Answer	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
5	YES[6]	YES[7]	NO[8]	NO	YES	YES[7]	YES	YES	YES	YES
6	YES	NO	NO	NO	NO	NO	YES	YES	YES	NO

YES[6] = Permitted in certain regions of Finland though not always with the consent of the local authorities.

YES[7] = Permissible but complicated and expensive because of special requirements which apply.

NO[8] = Only permitted in very exceptional circumstances.

Section 6.5 discusses the general situation with regard to the construction of petrol stations in important groundwater areas. Initial impressions suggest that, on the basis of the above results, it is possible to carry out petrol station construction in major groundwater catchment areas in almost any of the countries. However, construction of petrol stations in such areas requires particularly careful planning in order to ensure a high level of environmental protection. It is therefore surprising to find that in some countries it is permitted to use 1-wall underground tanks. In this respect Finland, in common with Russia, Spain and Sweden has a poor level of protection. In Germany, Hungary, Lithuania, Norway and United Kingdom there is a higher level of water protection if the use of 1- or 2-wall tanks at existing petrol stations in important groundwater areas is the determining factor.

5.1.4 Questions and responses omitted from the results

A number of questions and their answers were omitted from the results to the questionnaire. There are two reasons for this. Firstly, the answers do not add any value to the comparison of environment protection levels. Secondly, such responses revealed too much variation and inconsistency within the individual countries. However, it could be argued that this is indeed a result since it shows that in many countries certain issues are by no means clear-cut. On the basis of this, it was decided to omit questions 10, 14, 23, and 35 to 44 which read as follows:

Question 10
Is it a requirement under your country's legislation to build a factitious compaction structure (e.g. made of HDPE-membrane or bentonite) under and around the underground tanks?

Question 14
Under legislation in your country, is it permitted to sewer rain water from the forecourt and fuel filling area after discharging the oil separator's contents (e.g. to an open ditch)?

Question 23
Is it required under your country's legislation to make provision for tanker truck breakdowns on petrol station premises?

Question 35
Is there any mention in your country's legislation of a legal minimum distance between the filling pipe and the dispenser?

Question 36
Is it permitted under your country's legislation to install the filling pipe at the pump island?

Question 37
Is it required under your country's legislation to equip petrol stations with a gauging system (an electronic fuel level control system)?

Question 38

Is it sufficient under your country's legislation to fulfil the fuel level control system requirements manually by means of a dipstick (i.e. staff using a measuring rod)?

Question 39

In addition to having an electronic gauging system, is it also a requirement under your country's legislation to have a dipstick system?

Question 40

Is it a requirement under your country's legislation to keep a service manual at petrol stations and to ensure that all fuel equipment has a control programme?

Question 41

Is it a requirement under your country's legislation to install automatic fire alarm systems at petrol stations?

Question 42

Is it a requirement under you country's legislation to install automatic vandal alarm systems at petrol stations?

Question 43

Is it a requirement under your country's legislation to install oil separator alarm systems at petrol stations?

Question 44

Is it required under your country's legislation that petrol stations be equipped with leak detection systems (automatic alarms) for 2-wall storage tanks (controlling the space between 2 walls)?

Even though the above questions are extraneous to the results, the responses can be presented despite the broad range of dispersion. The letters Y/N in Table 5.8 below mean that both "YES" and "NO" responses have been received from the same country.

Table 5.8. Responses to the questions omitted from the final results.

Answer	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
10	NO	NO	NO	YES[10]	NO	NO	YES[10]	NO	NO	NO
14	YES	Y/N	YES	YES	YES	YES	YES	NO	Y/N	Y/N
23	Y/N	Y/N	Y/N	Y/N		Y/N	YES	YES	Y/N	Y/N
35	NO	NO	Y/N	NO	YES	YES	Y/N	NO	Y/N	NO
36	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES
37	NO	Y/N	Y/N	NO	NO	Y/N	YES	NO	Y/N	Y/N
38	YES	Y/N	Y/N	YES	YES	YES	Y/N	YES	YES	Y/N
39	Y/N	NO	YES	NO	NO	Y/N	YES	Y/N	YES	Y/N
40	YES[23]	Y/N	Y/N	NO	YES	Y/N	YES	Y/N	YES	YES
41	NO	Y/N	Y/N	NO	NO	Y/N	YES	Y/N	NO	Y/N
42	NO	NO	Y/N	NO	NO	NO	NO	NO	NO	Y/N
43	Y/N	NO	Y/N	NO	Y/N	NO	Y/N	Y/N	YES	YES
44	Y/N	YES	YES	YES	Y/N	Y/N	Y/N	YES	Y/N	YES

YES[10] = In Lithuania and Russia this applies to 1-wall tanks.

YES[23] = Applies to petrol station located in major groundwater catchment areas.

As table 5.8 shows, the responses produced a wide variation within and between countries. However, in the present study, the omission of the above questions and responses has very little impact on the final results or the conclusions. On the contrary, from a research perspective, the decision exclude them enhances the reliability of the overall results by minimising inconsistencies and dispensing with needless speculation.

Question 4, concerning groundwater areas, was omitted earlier. Inevitably, this would elicit a “YES” response because major groundwater catchment areas exist in all the countries investigated.

5.1.5 Supplementary questions

After sending the questionnaire to the respondents, it was realised that additional information was required. The following four supplementary questions were sent shortly after the main questionnaire:

Supplementary question 1.
According to your country's national legislation or requirements, is it permitted to refuel customers' vehicles on the forecourt at the same time as a tanker is filling underground tanks?

Supplementary question 2.
In your country, is it necessary to obtain any form of licence or qualification for the purpose of designing petrol stations?

Supplementary question 3.
In your country, is it necessary to obtain any form of licence or qualification for the purpose of constructing petrol stations?

Supplementary question 4.
In your country, is it necessary to obtain a licence or qualification for the purpose of installing fuel equipment at petrol stations?

The responses with brief comments are presented in Table 5.9 below.

Table 5.9. Responses to the supplementary questions.

Answer	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
Supp. 1	YES	YES	NO[1]	YES	YES	YES	NO	Y/N[2]	YES	YES
Supp. 2	NO	NO[3]	NO[4]	YES	NO[4]	YES	YES	YES	NO	YES
Supp. 3	NO	NO[3]	NO[4]	YES	NO[4]	NO[4]	NO[4]	YES	NO	YES
Supp. 4	NO	NO[3]	YES	YES	NO	YES	YES	YES	NO	YES

NO[1] = In Hungary this is not permitted, but for reasons of taxation rather than technology or safety.

Y/N[2] = In Spain this is dependant on the location of the filling area.

NO[3] = In Germany a licence or qualification is not mandatory, but working methods at petrol stations are supervised.

NO[4] = For petrol station projects no specific license or authorization is required, but generally in these countries companies need certification to operate in business.

This supplementary information was seen as relevant to the present study, particularly as these issues have come under increasing scrutiny in recent years because of their implications for safety and quality. In Finland, as in almost all the countries studied, refuelling of customers' vehicles is permitted while tankers are filling storage tanks. Responses to the questions about the need to obtain a licence and qualifications reflect changing attitudes in a number of the countries.

5.2 Results of the observation

The present Section also contains much significant information for making possible an assessment of the level of Finnish environment protection of petrol stations. In common with the previous Section, the assessment is made on the basis of the three main elements of environmental protection; **air**, **water** and **soil.** The results are all based on the observations made in the practical field investigation. Numbering sequence and colour codes are the same as those used in the previous Section.

5.2.1 Air protection

The observations regarding air protection contributed to and corroborated the results of the survey. The practical field investigation also made it possible to ascertain the extent of the installation of vapour recovery stage 1- and 2-systems. The results are presented in Table 5.10 below. They show that, with the exception of Russia, more than 90% of petrol stations in all of the countries are equipped with a vapour recovery stage 1-system. In Russia the percentage is only 48%. In Germany and Sweden the figure is 100% for vapour recovery stage 2-system. In Hungary there was only one single case of a petrol station not having a vapour recovery stage 2-system.

Table 5.10. Percentage (%) of the vapour recovery systems according to practical field investigation.

	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
Stage 1	99	100	100	96	100	90	48	100	100	100
Stage 2	40	100	98	93	3	70	30	4	100	6

In practice, despite the regulations in force, the air protection level in Finland is actually higher than in Russia since, here, such laws are commonly flouted. It is noteworthy that many petrol stations in Finland are in fact, equipped with vapour recovery stage 2-systems. Around 40% of Finnish petrol stations have a vapour recovery stage 2-system installed, though this is not a legal requirement. This latter fact explains the use of red and green for Finland in Table 5.10.

However, notwithstanding the above remarks, air protection levels in Finland were found to be considerably lower than in Germany, Hungary, Lithuania and Sweden. They are similar to Poland, though better than in Russia, Spain and United Kingdom.

5.2.2 Soil protection

The evaluation of soil protection levels is based on the following factors; pavement materials, drainage of forecourt and fuel filling areas, 1- or 2-wall storage tanks, 1-wall as opposed to 2-wall piping, inspection and operating procedures, and miscellaneous equipment. First-hand observation was used to examine pavement types and drainage of forecourt and fuel filling areas.

<u>Pavement types</u>

The practical field investigation examined the different types of pavement material used in the various countries. The results of this study are shown in Table 5.11 and Table 5.12.

Table 5.11. Percentage (%) of the forecourts' pavement types used in each country according to the practical field investigation.

Forecourts' pavements (%)										
Pavement	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
Asphalt	26	0	0	0	21	3	2	1	30	0
Concrete	3	100	20	7	5	25	6	89	10	60
Concrete brick	62	0	80	93	61	70	88	8	47	40
Asphalt + Concrete	6	0	0	0	3	0	0	0	5	0
Asphalt + Brick	3	0	0	0	10	3	4	1	3	0
Concrete + Brick	0	0	5	0	0	0	0	1	4	0

Table 5.11 shows that concrete is used extensively in both Germany and Spain. In United Kingdom the percentage of concrete is high, 60%. Generally, however, in other countries the most common material used for forecourts is concrete brick. In Germany a small number of forecourts were made of concrete slabs (not bricks) but these had oil-proof joints and were thus classified in the same category as concrete. The practical field investigation revealed that Germany was the only country where the joints between concrete slabs were actually oil-proof. All respondents confirmed, however, that when concrete bricks were used on forecourts, oil-proof sealing was, in fact, a requirement in every country.

Asphalt as a pavement material was mainly used only in the Nordic countries and, interestingly, not one example of such material was found in Germany, Hungary, Lithuania, Hungary or United Kingdom. In Russia there were two cases of asphalt being used in this way and only a single case in Spain.

Table 5.12. Percentage (%) by country of fuel filling area pavement type according to the practical field investigation.

FUEL FILLING AREA PAVEMENTS (%)										
Pavement	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
Asphalt	53	0	0	3	61	3	2	4	71	0
Concrete	25	100	27	32	2	26	22	90	16	94
Concrete brick	13	0	68	65	8	63	42	4	7	6
Asphalt + Concrete	4	0	0	0	3	3	0	0	5	0
Asphalt + Brick	3	0	0	0	6	1	6	1	1	0
Concrete + Brick	0	0	5	0	0	1	12	1	2	0
Other	2	0	0	0	21	5	16	0	0	0

In Germany, as Table 5.12 shows, the fuel filling areas are covered 100% by concrete and a high percentage was also found in Spain and United Kingdom. In the Nordic countries over half of the fuel filling areas are made of asphalt. However, in Finland, Norway, Poland and Russia there were a number of cases of fuel filling areas covered partly with gravel or grass, which is clearly an undesirable situation environmentally. These results are shown in the bottom row of the table as ’Other’.

According to the practical field investigation, which verified the results of the survey, it can be concluded that soil protection levels based on pavement type are lower in Finland than in Germany, Hungary, Lithuania, Poland, Russia, Spain and United Kingdom. Similar levels to Finland are found in Norway and Sweden.

Drainage of forecourt and fuel filling areas

The practical field investigation examined the distribution of drainage systems in each of the selected countries. The results are shown in Table 5.13 below.

Table 5.13. Percentage (%) by country of drainage systems according to the practical field investigation.

	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
Fore-court	99	100	100	99	19	96	94	99	61	100
Filling area	95	100	100	97	11	96	74	96	37	100

First-hand observation of drainage systems also bore out the results of the survey. The results above show that the situation was much the same in all of the countries with the notable exception of Sweden and Norway, where the level of soil protection is markedly lower. The practical field investigation also confirmed that in Finland the percentage of petrol stations having drainage systems is much higher than in the other Nordic countries. However, this was also noted in Section 5.1.2 in the responses relating to regulations. The situation in Germany, Hungary, Spain and United Kingdom is very positive with a response rate of 100%. According to the practical field investigation, the figure is only 74% for Russia despite the fact that drainage systems are required by law.

5.2.3 Problematic issues in Finland

In Finland, as mentioned in Sections 1.3 and 1.13, there has been a good deal of contamination of major ground water catchments areas and also at petrol station sites. In the present Chapter (Sections 5.2.3 and 5.3.8) a number of specific problems are examined. Some of these problems have been, at least partially, the actual causes of this contamination. This Section considers the problem of **pavements** and **fuel spillage** which can cause contamination when the pavement type has **inadequate resistance to petrol and diesel oil.**

An important body, Safety Technology Authority, in on of its regulation [53] stipulates the construction of a factitious compaction structure whatever the pavement type.

As a result of the contradictory nature of the guidelines, construction of a factitious compaction structure layer under the pavement is not always carried out. This ambiguous situation has meant that regional or local authorities have sometimes withheld approval for newly constructed or renovated stations which do not have a factitious compaction structure under the asphalt pavement [30]. The interests of no party are served by such unclear regulations. A recent example of a damaged forecourt is presented in Figure 5.1.

Fig 5.1. A hole caused by fuel spillage on an asphalt forecourt pavement made of asphalt. Matchbox indicates scale.

Previous studies [46] have demonstrated that asphalt is not a suitable pavement material for forecourts and fuel filling areas. Additionally, it is claimed [3] that bitumen, the adhesive of asphalt, does not have adequate chemical resistance to petrol and diesel oil.

A certain amount of fuel spillage is to be expected on forecourts and fuel filling areas. Frequently, at petrol stations liquid fuel splashes and spills onto the pavements of forecourts and fuel filling areas. The splashes are caused by overfills during refueling of customers' vehicles at the forecourts and also by tanker drivers at the fuel filling areas. The type of pavement material used for construction should, therefore, be suitable for such common occurrences.

Similar damage to that presented in Figure 5.1, albeit on a smaller scale, has occurred at hundreds petrol stations throughout Finland. This kind of damage, caused by fuel spillage, has been observed extensively during the Finnish field studies for this research. As Figure 5.1 demonstrates, fuel spillage causes large holes to form in the asphalt pavement. Without a factitious compaction structure under the pavement, the fuel has direct access to soil and water. The construction of forecourts and filling areas using materials resistant to fuel spillage would have prevented a good deal of contamination.

5.3 Administration, legislation and regulations

The Relevant Finnish Authorities

Identifying the Finnish authorities and their actual role in this area are not in themselves intended to form a major topic of the present study. Its relevance, however, is that such organizations make it possible to determine the extent of the practical issues involved. In the Finnish oil industry the authorities exist at the level of state, region and municipality.

5.3.1 State authorities

Authorities at the state level are not directly involved in individual petrol station projects. Their responsibilities are largely confined to the preparation of laws and other regulations and to issuing pronouncements. The state authorities comprise the following agencies:

- Government (VN)
- Ministry of Trade and Industry (KTM)
- Ministry of the Environment (YM)
- Ministry of Social Affairs and Health (STM)
- Ministry of the Interior (SM)
- Safety Technology Authority (Tukes)
- Finnish Environment Institute (SYKE).

The major responsibility of the state authorities is to enact legislation. The Government has implemented the EU Directive [15, 21] of VOC emissions. With regard to environment protection, the most important authority is the Ministry of the Environment which has passed the Environment Protection Act [12], the Environment Protection Decree [13], the Land Use and Building Act [42] and the Land Use and building Decree [43]. The Finnish Environment Institute acts under the jurisdiction of the Ministry of the Environment at the state level. The Ministry of Trade and Industry oversees the technological aspects of petrol station operations. The Safety Technology Authority functions under the Ministry of trade and Industry and is responsible for the prevention of fires and explosions. The municipality rescue authorities are headed by the Ministry of the Interior. Occasionally, the municipal environment authority is one and the same organisation such as the health authority which is governed at the state level by the Ministry of Social Affairs and Health and, therefore, listed here.

5.3.2 Regional Authorities

Like their counterparts at the state level, regional authorities do not normally participate in the process of granting permits for petrol stations. Only in very exceptional cases do they play a regulatory role in individual petrol station projects, though they are kept informed by the municipal authorities on particular projects

The regional authorities consist of:

- Safety Technology Authority's regional offices and

- Regional Environment Centres.

The Regional Environment Centre will normally express an opinion when permits are being sought for new or renovated petrol station. In cases involving the issuance of permits for contaminated petrol station sites, the regional environment centre almost always plays an active role in the project.

5.3.3 Municipal Authorities

The most important authorities for the oil companies, designers and contractors are the municipal authorities since these bodies play the most important role in adjudicating petrol station permit applications. The municipal authorities consist of:

- Environment Protection Authorities

- Fire and Rescue Departments

- Chemical Authorities

- Building Authorities.

In each project the oil company, designer and contractors must normally deal individually and separately with each municipal authority.

The primary responsibility of the municipal authorities with regard to petrol stations is the administration and granting of environmental permits and also monitoring inspections of their operations. The body overseeing this is the Environment Committee. The practical functions are carried out by personnel such as the Head of Environment Protection Office, Environment Protection Inspector or Environment Protection Secretary.

In the Fire and Rescue Departments, fire inspectors and chemical inspectors normally deal with permit applications as well as the required inspections. Building authorities, despite operating independently of the environment authorities, nowadays often come under the auspices of the municipal Environment Committee. The building authorities are responsible for processing building permits and supervising construction operations.

5.3.4 Comparison of the number of authorities in the selected European Countries

It was clearly impossible to study every individual regulatory authority in each of the countries selected. As a result, it was decided to classify them according to the following categories; countries having:

- fewer authorities than Finland
- more authorities than Finland
- a similar number of authorities to Finland.

As Table 5.14 below shows, there are two countries, Hungary and Sweden, with a similar number of authorities to Finland. Norway, Spain and United Kingdom have fewer while Germany, Lithuania, Poland and Russia have more.

Table 5.14. Number of authorities in the oil industry for selected European countries.

Number of regulatory authorities		
Less than Finland	More than Finland	Similar to Finland
Norway Spain United Kingdom	Germany Lithuania Poland Russia	Hungary Sweden

It should be mentioned here that the number of authorities fluctuates in each of the selected countries and there appears to be no discernable correlation between the number of these regulatory bodies in any particular country and the level of environmental protection.

Laws, legislation, statutes, regulations and standards

Legislation determines petrol station construction and operational procedures in each of the selected countries and because of this laws, statutes and regulations have major technological significance for the oil industry. In consequence, it is important that such legislation is consistent and harmonised to ensure there are no contradictory requirements.

It is not, however, the purpose of the present study to examine international standards such as the EN- and ISO-standards or standards for fuel equipment. Despite their being very important standards, they do not have any legally enforceable impact on the operations of petrol stations nationally.

5.3.5 Legislation, regulations and standards for petrol stations in Finland

The following are the items of legislation, regulations and standards which have a bearing technologically on the operations at petrol stations in Finland:

- Chemicals Act 744/1989 [5]

- Chemicals Decree 675/1993 [6]

- Decision of the Ministry of Trade and Industry on Inflammable Liquids 313/1985 [8]

- Decision of the Ministry of Trade and Industry on the Handling and Storage of Dangerous Chemicals at Distribution Stations 415/1998 [9]

- Decree on the Industrial Handling and Storage of Dangerous Chemicals 59/1999 [10]

- Environmental Protection Act 86/2000 [12]

- Environmental Protection Decree 169/2000 [13]

- Government Decision on the Limitation of Emissions of Volatile Organic Compounds due to the Storage and Distribution of Petrol 468/1996 [21]

- Land Use and Building Act 132/1999 [42]

- Land Use and Building Decree 875/1999 [43].

There are also other laws which have an influence on petrol station activities such as the Act on Water Services 119/2000, the Act on Combating Oil Pollution on Land 378/1974, the Act on Neighbourhood Relationships 26/2000, the Waste Act 1072/1993, the Waste Decree 1390/1993 and the Act of Compensation for Environmental Damage 737/1994. Whilst these items of legislation are enforceable, they do not have a direct bearing on petrol station construction.

Additionally, there are various other important regulations and guidelines and while not legally enforceable, they are nonetheless considered influential. Such regulations include, in particular:

- Changed Obligations for the Petrol Stations, 2000 [4]

- Finnish Oil and Gas Federation's Guidelines for Applying the Decision 415/98, 2001 [25]

- Flammable Liquids Service Stations SFS 3352, 4th Edition, 2004 [59]

- Petrol Stations. Safety Technology Authority's Precept to the Regional and Local Authorities, 2001 [53].

As noted earlier, there is no obvious hierarchy among the above guidelines. Depending on their position as participants within the oil industry, each of the interested parties applies and interprets the regulations in different ways. It is not the purpose here, however, to discuss these different perspectives in full.

From the legal standpoint, the Safety Technology Authority has the right to interpret Decision 415/1998 [9] 4 §.

> ”Safety Technology Authority nominates the standards, which will completely or partly fulfil the requirements of this decision.
>
> Safety Technology Authority can give consistent technological and safety directions for applying this decision.”

This makes it clear that the Safety Technology Authority's Precept to the Regional and Local Authorities [53] takes precedence over the Standard SFS 3352 [59] or the Finnish Oil and Gas Federation's Guidelines [25]. Naturally, it is also possible to implement those regulations which are lower in the legislative hierarchy, provided they do not conflict with the Decision 415/1998 [9] and the Safety Technology Authority's Precept [53].

5.3.6 Comparing legislation, regulations and standards in the selected European Countries

As with the authorities, it was clearly impractical in the present study to examine every single item of legislation in each of the selected countries. Three categories were, therefore, created to classify each country according whether it has **fewer** or **more** regulations than Finland or a **similar** number.

These categories are presented in Table 5.15 below. They closely resemble the distribution of regulatory authorities contained in Table 5.14, though Lithuania and Spain reverse positions.

Table 5.15. Number of regulations in oil industry.

Number of regulations		
Less than Finland	More than Finland	Similar to Finland
Lithuania Norway United Kingdom	Germany Poland Russia Spain	Hungary Sweden

5.3.7 European Union directives

The best known directive within the oil industry is *EU Directive 94/63/EC. Control of Volatile Organic Compound (VOC), Emissions resulting from the storage of petrol and its distribution from terminals to petrol filling stations* [15] which was issued on 20th December, 1994. It was formally adopted in Finland on 19th of June, 1996 as the *Government Decision on the Limitation of Emissions of Volatile Organic Compounds due to the Storage and Distribution of Petrol 468/1996 [21]*.

Another important directive (98/70/EC) relates to fuel quality. According to this, only the sale of sulphur-free fuel will be permitted in the member states from the beginning of 2009.

There are also other directives currently being drafted that will, in varying degrees, affect the oil industry. In addition to directives, numerous standards are in the process of being defined by the European Union’s CEN Technical Committee 21 which deals with different types of fuel equipment.

5.3.8 Findings of problems in Finland

Before examining such problems, it is first worth considering an example typical of the complex and contradictory nature of the Finnish regulations relating to this area of environmental protection. In 1997 the Finnish Oil and Gas Federation recognised the need to introduce a new standard which would include the latest technological knowledge and incorporate stringent requirements to meet the demands of modern petrol stations while also conforming to existing regulations. At about the same time, the *Decision of the Ministry of Trade and Industry on the Handling and storage of Dangerous Chemicals at Distribution Stations, 415/1998* [9] was also published which was and still remains the most important piece of legislation for the Finnish oil industry. Decision 415/98 contains various requirements governing not only new petrol stations but also existing ones. The deadline for fulfilling these requirements was set at the end of 2002. Then, in 1997, the Finnish Oil and Gas Federation needed to make a decision for creating a new standard.

Between 1998 and 1999, a committee was set up to draft this new standard and began its work in 2000. The first proposal was submitted in September 2002 and almost immediately it was decided that the proposal would be published in December of the same year or by the beginning of 2003, at the latest. At the same time, the deadline for fulfilling the requirements of the Decision 415/1998 was approaching but this was suddenly extended to September 2003 to allow more time for fulfilling the requirements of the aforementioned Decision 415/98. After some delay, the second proposal for the new standard was eventually presented in September 2004. The new standard was contained in *Service station for flammable liquids SFS 3352, 4. Edition* [59], which was eventually published in December 2004. Unfortunately, this standard, despite its claim to being the BAT reference document, was received with disappointment by the oil industry [29, 30, 31, 32]. Section 5.3.9 presents a more detailed evaluation of the standard 3352.

<u>Underground spaces beneath forecourts</u>

On the issue of empty underground spaces such as chambers and channels beneath the forecourt, the Finnish regulatory authorities also appear to be in disaccord. One set of regulations forbids the existence of spaces beneath forecourts because fuel vapour may enter, while another regulation makes the contrary requirement, namely that such spaces should indeed exist. Another regulation contains contradictory advice, recommending that the selection of infilling material (e.g. sand, mineral wool) for underground spaces should be determined by the need to ventilate such spaces. [9, 29, 30, 31, 32, 37, 40, 41, 48, 55, 59, 61]

The reason for prohibiting empty spaces beneath forecourts is the danger of explosion and there have been a number of recorded cases where explosions have resulted from petrol vapour seeping into these underground spaces. At present none of the parties involved, including the authorities, are agreed on the best solution to this problem because existing regulations are contradictory. So far, none of the authorities has made any proposal to clarify the present confused situation. [40, 41, 48, 55, 61]

In Finland a recent ATEX-directive [14, 16, 22] was implemented for petrol station projects in 2004. According to the provisions of this directive, all oil companies are required to draw up a risk analysis for explosive spaces at every petrol station. While it is still too early to obtain details of the effect of this directive, it is likely that the ATEX-directive will make a positive contribution to resolving the issue of underground spaces beneath forecourts.

Petrol stations and major groundwater catchment areas

During recent years there has been much discussion about petrol station design and the granting of construction permits on sites located in major groundwater catchment areas. [29, 30, 31, 32]

Despite expressions of concern, however, there is still a lack of any uniform policy among the various regions in Finland when approving applications and granting permits for petrol station construction. Even in identical circumstances, the authorities in one region will grant a permit while in another, it is withheld.

In one particular region in Finland, for example, the authorities insisted on the removal of an existing petrol station because of its location in a major ground water area. Paradoxically the authorities in the same region have granted approval for construction of a new petrol station in the same catchment area. [29, 30, 32]

<u>Contradictory regulations</u>

There are many contradictions among the regulations currently in force. A clear example of these contradictory regulations is to be found in the *Decision of the Ministry of Trade and Industry on the Handling and Storage of Dangerous Chemicals at Distribution Stations, 415/1998* [9]. Here it is explicitly stated that joints in underground steel petrol pipes (suction and filling) must be made by welding, thus making it illegal the use threaded metal petrol pipe joints in underground installations from January 2003 and later extended to September 2003. The implications of this requirement were far-reaching and, in 1998, this called for the reinstallation of a major part of the petrol piping at petrol stations throughout Finland.

For the oil industry such major reinstallation work was not easy to implement and it was not surprising, perhaps, that this requirement was not readily followed. As a result, about one year before meeting the deadline for fulfilling this requirement, 1st of November 2001, the Finnish Oil and Gas Federation distributed, *Guidelines for applying the Decision of the Ministry of Trade and Industry on the Handling and Storage of Dangerous Chemicals at Distribution Stations 415/1998* [25]. The guidelines reflected the oil companies' view that, for economic reasons, the Trade and Industry Ministry's requirements could not be implemented retrospectively. Though the Finnish Oil and Gas Federation has no legal power to enforce its authority, in practical terms it does enjoy special status as a major authoritative body in Finland. As a result, many parties in the oil industry have felt secure in following the above mentioned guidelines.

However, the situation in the field remained unclear. Eventually, on 13th December 2001, the Safety Technology Authority, a body empowered with legal authority, published the statement, *Petrol Stations. Safety Technology Authority's Precept to* *the Regional and Local Authorities* [53]. The statement reaffirms the legal status of the requirements governing petrol pipe joints which were contained in the original decree, Decision 415/1998 [9].

Despite these attempts to set the record straight through legislation, in practice the situation remains unclear. Throughout Finland there are still hundreds of petrol stations which have underground steel petrol pipes containing threaded joints, in contravention of the regulations.

Local authorities' terms of approval

There are also many differences between the various local authorities in Finland in dealing with petrol station applications. Such discrepancies are unprofessional and occasionally result in the unfair treatment of the oil companies and other interested parties. Sometimes the authorities require the installation of real time alarms, gauging systems, operation inspections and vapour recovery stage 2-systems, even if these are not specifically required under the regulations. Despite the desirability of such requirements from an environmental viewpoint, such inconsistencies are serious obstacles in the petrol station planning process. Carrying out operations like cost estimation, design and construction are all made more difficult when it is not known in advance how the regulatory bodies will ultimately react. [29, 30, 31, 32]

It may not be fair to accuse the authorities of being deliberately obstructive or partisan in the granting of approval permits for petrol station but the lack of clear regulations and inconsistency may sometimes make it appear so.

Licensing designers and contractors

In Finland almost anybody can work as a designer or a contractor on petrol station projects. Finnish law and other regulations do not require any special licence or accreditation for those employed on petrol station construction, renovation or maintenance projects. Similarly, the fuel equipment installation companies are permitted to operate without any type of licence. In petrol station projects, there are many instances of damage discovered not only during but also after the construction and installation process. Much of this is directly attributable to insufficient know-how and a lack of skilled manpower on the part of companies who are themselves often highly regarded as civil engineers and plumbing contractors [29, 30, 31, 32].

The above observations relate to practical problems and are not made with the intention of apportioning blame. They are presented here merely to indicate the extent of the difficulties involved in the field of regulation. They need to be addressed before solutions can be found to the many problems faced in the Finnish oil industry.

5.3.9 Service station for flammable liquids SFS 3352, 4. Edition, 2004

The fourth edition of the standard *Service station for flammable liquids SFS 3352* [59] has been received with a good deal of interest by the oil industry [20, 29, 30, 31, 32, 38, 55, 60]. It is believed that this latest version would contain definitive modern solutions to the technical problems encountered by petrol stations and also fulfil safety and environmental requirements. In addition, it is claimed that the standard contained in this edition is based on the latest and most advanced know-how [38, 60]. This is one reason why it has been considered unnecessary in Finland to draw up any form of BREF-document or national BAT-report [29]. The standard [59] has, in fact, been accorded the status of a BREF-document [29, 38, 60, 65]. However, it is worth noting in this context that the European Commission is the only body able to confer BREF-document status.

The standard [59] includes much relevant information about fuel equipment, piping, forecourts, fuel filling areas and numerous other petrol station facilities. In many respects it is an admirable document whose contents are clear, comprehensive and well-presented. Despite being an impressive publication, however, it cannot realistically be considered a BAT Reference Document. According to the standard SFS 3352 [59] it is, in fact, possible to construct petrol stations without necessarily employing all the best available techniques. This is no baseless assertion since the standard states that petrol station construction can be undertaken according to the following guidelines:

- 1-wall underground tanks are allowed

- 1-wall suction and filling pipes are allowed

- underground tank chamber need not be the same as the vapour density

- underground steel pipe thread joints are permitted when the pipe is located in a channel or chamber

- asphalt is allowed as a paving material on forecourts and fuel filling areas

- a factitious compaction structure is not needed under the pavement of the forecourt or the fuel filling area if the pavement is made of concrete (h=200 mm) or dense asphalt (void contents under 3%, polymeric modification bitumen admixture, two layers)

- vapour recovery stage 2-system is not required

- electronically operated gauging system is not required.

Few in the industry would agree that petrol station construction according to the above guidelines conforms to Best Available Techniques. It is believed here that such guidelines could easily be replaced at reasonable cost by more environmentally friendly solutions.

The standard SFS 3352 [59] also contains information that contradicts existing legislation as the following examples demonstrate.

Nominal pressure of steel pipes

The *Decision of the Ministry of Trade and Industry on the Handling and Storage of Dangerous Chemicals at Distribution Stations, 415/1998* [9], 15 § states that the nominal pressure of filling pipes must be at least 10 bar. However, according to the standard SFS 3352 [59] the nominal pressure of steel pipe is claimed to be 6 bar. That is a very important detail which could give rise to serious problems in practice.

Safety distances of tanks

The *Decision of the Ministry of Trade and Industry on Inflammable Liquids 313/1985* [8], 24 §, states that the safety distances between aboveground tanks is set at one meter. According to the new standard SFS 3352 [59] however, the safety distance is set at 2 meters.

Petrol stations on agricultural sites

According to the standard SFS 3352 [59] is not necessary to construct drainage to the forecourt or to the filling area when the petrol station is located on an agricultural site, irrespective of tank capacity. Decision 415/1998 [9], 2 §, states that on farms, this decision does not apply if total tank capacity is less than 10,000 litres. Again, such a discrepancy could have unfortunate environmental repercussions.

Furthermore, the standard SFS 3352 [59] makes no reference to the *Environmental Protection Act* [12] or *Environmental Protection Decree* [13] which are major items of legislation for the oil industry. Indeed, the standard even fails to make any mention of the terms **environment protection** and **BAT**. In this context, it has to be concluded that the standard *Flammable Liquids Service Stations SFS 3352 4th edition* [59] does not warrant the status of BREF.

5.4 Permission procedures

Permits required in petrol station construction

5.4.1 Finland

The following are the permits and applications required in Finland for the construction of petrol stations:

- **Environment Permit**

  - The legal basis for the environmental permit is set out in the Environmental Protection Act [12].

  - The Environment Permit is required for any kind of activity that could result in contamination of the environment.

  - It is always required for a new petrol station or for an existing one undergoing major renovation [13].

  - Administration of the Environment Permit is the responsibility of the Environment Protection authorities.

- **Building Permit**

  - The legal basis for building permits is set out in the Land Use and Building Act [42].

  - The Building Permit is always required for any building or existing building undergoing major renovation.

  - It is always required for a new petrol station project, though in the case of renovation projects this requirement is dependent on the extent of the renovation.

  - Administration of the Building Permit is the responsibility of the Building authorities.

- **Application of Chemical Handling**

  - The legal basis for the Application of Chemical Handling is set out in the Decree on the Industrial Handling and Storage of Dangerous Chemicals [10].

  - The Application must always be made before a new petrol station is commissioned. This also applies to existing petrol stations undergoing renovation.

  - Administration of the application is undertaken by the Fire and Rescue and/or Chemical authorities.

Depending on the Master Plan itself, it may sometimes also be necessary to obtain an Exceptional Permit when the site is within a designated area on the Master Plan.

All the above permits are processed by the relevant local municipality. In Finland there are about 400 municipalities and so it would be surprising to find complete nationwide uniformity of practice among so many diverse individuals and municipal committees. Indeed, this is seen as the main reason why the permit issuing process lacks consistency throughout country.

5.4.2 Comparison of permit requirements in selected European Countries

It is difficult to present any systematic and detailed international comparison concerning permit requirements. However, based on the interviews conducted during this study, it is possible to make a general evaluation of the situation.

In Lithuania, Poland and Russia only one single permit is required for petrol station construction projects. Despite this, however, the permit application and granting process is a good deal more complicated and protracted than in Finland. The process involves numerous stages and approval must also be obtained from several authorities. In Germany the permit granting process is also more difficult than in Finland. One of the major reasons for this is that in Germany each of the 16 Federal states issues its own separate set of regulations governing such matters as the protection of soil and water.

According to the results of the personal interviews, the permit granting process in Hungary, Norway, Spain, Sweden and United Kingdom is much the same as in Finland. In these countries an Environment Permit and a Building Permit are required along with approval or a licence from the local fire authorities.

5.5 Other results

The present study also contains a number of subsidiary findings which may have implications for the future.

5.5.1 Method

This research and the methods adopted here, are a combination of survey and observation as well as risk analysis. Together they provide information which is both reliable and repeatable. First-hand observation supported the results of survey. The results can be applied to other industrial sectors, particularly in the chemical industry and wherever there is a need for environment protection.

5.5.2 BAT

BAT-principles have not been fully adopted in Finland and the regulations for applying BAT are not always being observed at petrol stations. This study examined tens of environmental permit applications and environmental permit decisions. In not one of these wewe BAT specifications explained. It was very common that only a cursory reference was made to the topic, in which it was noted: *"According to the best know-how the fuel equipment presents the best available techniques."* This single mention of BAT seems to have satisfied both the authorities and the oil companies even though it was never made explicit what the term actually means.

5.5.3 Risk analysis

Risk analysis can be developed by applying the findings presented in Appendix 1. When applying risk analysis to an individual petrol station it is, of course, necessary to assess risk probability and significance in terms of the prevailing local conditions.

However, from the point of view of the researcher's employers, the risk analysis developed here can be regarded as a result in itself. In practical terms, it provides a tool for finding the "weakest link in the chain" at the each petrol station. Depending on the project, the risk analysis process helps identify the best ways to efficiently minimize hazards and danger.

In the course of this study one particular subject of interest was the contents of the proposed REACH-regulation [52]. These proposals, which are directed at the chemical sector, will require that the industry devises risk analyses of chemicals they produce. By inspecting these risk analyses, the authorities will be better placed to carry out monitoring and random tests. A similar scheme is recommended for petrol station projects as well.

5.5.4 Control diary of the petrol station's environment

A "control diary" in the form of a documentary record was maintained throughout the present study. This provided a straightforward way of helping to reduce environmental damage and improve safety and security. This record also serves as a basic maintenance tool, saving costs and extending the lifetime of petrol stations by means of a controlled programme of monitoring.

The control diary is composed of contact information pages, listed equipment and the functions to be monitored, an itemised monitoring schedule, site plan and separate control pages to be completed during inspections of the petrol station.

From a business perspective, such a record can be regarded as another practical outcome of the present study.

6. DISCUSSION

6.1 General

This study examines the level of environmental protection standards at petrol stations in ten European countries. A central objective here is an international comparison of Finnish environment protection levels and also finding ways for creating more efficient environmental protection in Finland. The other countries selected for the collection of data were Germany, Hungary, Lithuania, Norway, Poland, Russia, Spain, Sweden and United Kingdom. Together they provide a representative cross-section of European countries on which to base a comparison with Finnish levels of environmental protection. Three of these countries, Norway, Russia and Sweden also share a common land border with Finland.

The research and the means by which it has been conducted, a combination of survey and observation, together provide a corpus of data that is both reliable and verifiable. Additionally, practical onsite observation corroborates the results of the survey. The outcome of this study can also be applied to other industrial sectors, the chemical industry in particular, but also wherever environment protection is a key issue.

The results and the experience gained during the study demonstrate that risk analysis is a suitable approach for determining the essential and harmful impacts on the environment. Answers were also found to all the research questions posed in Section 1.13. It is hoped that these results will be of benefit to the Finnish oil industry in developing environmental standards at petrol stations in the country. The study evaluated the relative level of environmental protection in Finland and several ways were found to improve the effectiveness of environment protection at petrol stations. Though no specific technological innovations are proposed, it is believed the outcome of this research project will provide new and useful information of benefit to the oil industry. Though it is not usually possible to import legislation and common practice from one country to another, there is nonetheless, much to be gained from international experience and know-how for improving environmental standards at Finnish petrol stations.

In recent years, Finnish regulations in this sector of the oil industry have become increasingly stringent, particularly those contained in the *Decision of the Ministry of Trade and Industry on the Handling and Storage of Dangerous Chemicals at Distribution Stations 415/1998 [9]*. However, despite this encouraging trend, there is still room for improvement in the legislation. One positive finding of this study was the fact that, overall, Finnish companies do conscientiously observe the relevant rules and regulations. Moreover, it would perhaps be surprising if there was no room at all for improving future legislation.

6.2 Environmental protection levels in Finland

As previously stated, there is certainly no cause for complacency with regard to levels of environmental protection at Finnish petrol stations. In fact, the results suggest quite the reverse. They show that Hungary, Germany, Lithuania, Poland, Spain and United Kingdom enjoy higher levels of environmental protection with Germany and Hungary having much higher levels than Finland. On the basis of legislation, Russia, too, appears to have higher levels than Finland. In practice, however, this was not found to be the case; the practical field investigation in Russia revealed that the regulations in force were routinely ignored.

The field investigation also showed that in Poland, too, some companies failed to fulfil all the statutory requirements. However, even allowing for this, overall levels of protection in Poland were found to be higher than those in Finland.

These observations are based on the fact that in each of the countries mentioned above:

- installation of **2-wall underground fuel tanks** is compulsory at every station

- **inspection and control programmes** of the tanks and fuel equipment is mandatory

- specifications for materials used on **forecourts** and **fuel filling areas pavements** are more stringent.

Additionally, in Hungary, Germany, Lithuania and Poland all petrol stations must be equipped with vapour recovery stage 2-systems. In terms of a comparison between Germany, Hungary, Lithuania, Poland, Spain and United Kingdom, the highest levels of environment protection were found in Germany and Hungary. This was because in these countries the installation of 2-wall filling pipes is a compulsory requirement. The practical field investigation also found that all the legal requirements were being followed in these two countries. In the United Kingdom 2-wall filling pipes are also legally required, though not vapour recovery stage 2-systems.

Levels of environmental protection similar to those in Finland were found in Sweden. When considering only levels of air protection Sweden fared better, but because of recent improvement repairs at Finnish forecourts and fuel filling areas, overall protection levels were much the same in both countries. This conclusion is based on the fact that vapour recovery stage 2-systems is a legal requirement in Sweden but not in Finland. However, were it not for such well-managed air protection standards, environment protection levels in Sweden would be lower than those in Finland.

Perhaps the most unexpected finding of the study is that Norwegian levels of environment protection are so low by international standards. In Norway, surprisingly, the level of environment protection appears to be markedly lower than in Finland in every respect. Another counter-intuitive finding of the study was that overall, environment protection levels in both Finland and Sweden were so clearly inferior to most of the countries investigated. On the other hand, in terms of legislation, Russian standards might initially appear higher than those in Finland. However as the field survey confirms, practice does not always follow precept and in the circumstances, this came as no surprise.

6.3 Administrative procedures

Administrative procedures and the paperwork they generate seem to be inevitable features of modern life and common to all societies. This was certainly found to be the case, to varying degrees, in all the selected European countries. Despite the fact that administrative practices play a significant role in public life in Finland, they were also shown to play an even greater role in some of the other countries studied. Nonetheless, the research results showed that administrative practices do not in themselves have any significant impact on levels of environment protection.

As already noted, all the various parties involved in the oil industry in Finland dutifully heed the regulations in force. Indeed this was borne out by the results of the practical field investigation, which involved visits to 409 petrol stations across the country. All Finnish oil companies promptly installed vapour recovery stage 1-systems and drainage systems at fuel filling areas as required by the existing regulations. Since the publication of the *Decision of the Ministry of Trade and Industry on the Handling and Storage of Dangerous Chemicals at Distribution Stations 415/1998* [9] Finnish oil companies have already fulfilled almost all the requirements contained in the document.

Nonetheless, even if administrative red tape has not seriously hampered technological operations at petrol stations, there is still scope for streamlining administrative practices in Finland.

It has already been noted above that in Finland there are separate authorities responsible for different aspects of environmental protection at petrol stations. At present these bodies come under the jurisdiction of three different ministries: ***Ministry of the Environment***, ***Ministry of Trade and Industry*** and ***Ministry of the Interior***. It seems reasonable to consider if such an arrangement might have an adverse impact on the overall standard of environmental protection at petrol stations in terms of legislation and administrative practices. In addition, the administration of petrol station permit applications in Finland is carried out separately by each of the 400 or so local municipalities. Such a system is vulnerable to the drawbacks inherent in such fragmentation. It may also explain the wide disparity in the technical specifications required by municipal authorities when approving permit applications. A more unified approach, therefore, might help in harmonising these procedures. The bodies best suited to achieve this are the Regional Environment Centres, who would assume responsibility for permit applications and enforcement the regulations.

In Finland the supervision and regulatory practices of the official authorities seem to vary from one municipality to another. One explanation for this is given above. Where the municipal authorities are controlled by higher level organisations there will often be a considerable overlap in the execution of some functions while other functions will be neglected. This could occur at different stages of a project; at the permit stage, at the construction supervision stage or during the follow-up monitoring stage of the project.

6.3.1 Developing the administrative practices

At present there seems to be no immediate prospect of a single European Union law or equivalent regulation being enacted to cover petrol station operations in all of the member countries. It therefore remains the job of each individual member-state to adopt the best available techniques (BAT) in carrying out its own projects. One of the most interesting conclusions of the present study is the negligible extent to which the European Union influences the everyday operations at petrol stations.

The wholesale imitation of practices employed abroad is not being advocated here. However, despite Finland's somewhat unique climatic conditions, there is still much to be gained from the experiences of other countries. If lessons are learned, these should be applied wherever possible**.**

Ideally, in Finland there should be only one single law to regulate the activities of petrol stations. If this is an unrealistically optimistic target in the short term, it is certainly an objective to be set for the future. One single comprehensive law would help clarify the regulatory requirements for the oil industry and at the same time, streamline the administrative practices of the authorities. As mentioned in Section 6.4 above, the standard *Service stations for flammable liquids SFS 3352, 4th Edition. 2004 [59]* does not contain all the necessary information on environment protection levels at Finnish petrol stations. Despite claims to the contrary, it makes the present situation even more obscure.

As with the "one law principle" there is also a need in Finland to create and adopt a "one permit principle" and a "one bureau principle." Under existing legislation a number of different permits are required for petrol station projects and these are handled by a variety of administrative offices. If only a single permit was required and this was issued by a single official body, the savings in time and resources might be diverted towards the goal of more efficient environment protection.

The process of obtaining several permits from a number of different issuing authorities is not only cumbersome but also vulnerable to error. For example, there could be too many issues to be checked and investigated when numerous parties are involved in the permit validation process. It is also possible that one authority will ignore technical matters that are believed to be the responsibility of another authority. The process involved in the granting of permits needs to be overhauled to make it more flexible and efficient.

The subject of administrative practices and procedures raises the question as to which official body is best equipped to deal with environmental protection at Finnish petrol stations. In terms of experience and organisational capacity, there are two obvious candidates, namely the ***Ministry of the Environment*** or ***Ministry of Trade and Industry***. These two authorities should undertake the harmonisation and clarification of existing legislation in order to rid the industry of confusing and contradictory requirements.

At the municipal and practical level, irrespective of the administrative area, granting permits and site inspections could be undertaken by groups composed of specialists with the required technological and administrative skills. The principal of “one law”, “one permit” and “one bureau” should not imply, however, that only one individual should be involved in the process. The overall purpose of these principles is to ensure the pooling of expertise and administration at the same location.

The basic justification for advocating “one law”, “one permit” and “one bureau” is that petrol station premises are the sites of flammable and explosive liquids and these are potentially dangerous to the environment and individuals alike. It would seem reasonable and practical, therefore, to establish a single administrative body to be responsible for the protection of both these risk groups.

In Finland, during the last decade there have been calls for abandoning the practice of issuing permits and replacing it with a system of self-regulation whereby the oil companies would simply notify the authorities of their compliance with environmental standards. However, legislation based on such a declaration procedure is open to abuse. In a business context in which profits take precedence over environmental considerations, such an alternative could would be disastrous. In fact, according to the results of the survey, permits are required in all the selected countries studied.

6.3.2 Contradictory regulations

As mentioned already, there are numerous contradictions in and between the regulations currently in force. In the light of this, it is difficult to understand why the authorities, instead of adding to the confusion, should not have issued clear and explicit guidelines for the benefit of all parties involved. Unfortunately, the official Finnish authority, the Safety Technology Authority and the influential but unofficial Finnish Oil and Gas Federation, instead of harmonising the regulations, have both left the decision-making process to the local authorities, designers, contractors and the oil companies. [25, 53]

6.4 BAT

BAT-principles have not been fully adopted in Finland. Legislation has been of very little help in clarifying the situation. The Environmental Protection Act [12] requires the implementation of BAT but in practice, by applying different legislation, it is indeed possible to construct a petrol station without observing BAT. One of the claims of the present study is that all the parties in the oil industry have failed to appreciate fully the significance and purpose of The Environmental Protection Act [12] and The Environmental Protection Decree [13]. This is true not only of the oil companies, designers and contractors, but the authorities as well.

In order to improve levels of environmental protection and substantially reduce hazards at petrol stations, new measures need to be adopted. These entail the overall standardization of the legislation along with the mandatory implementation of BAT principles. In addition, there needs to be greater clarification of the roles of the authorities as well as development of self-regulation and inspection programmes. These should also be undertaken in collaboration with the oil companies. Indeed, the specified BAT principles would greatly help to expedite the permit granting process and, it is believed, environment protection levels would also be raised.

6.5 Petrol stations in major water catchment areas

In recent years there has been much discussion in the oil industry and the media concerning petrol station operations in major groundwater catchment areas. According to the findings of the present study it is, in practice, possible to construct a petrol station in major groundwater catchment areas in almost all of the selected countries even though there may be special conditions which must be fulfilled. In general, petrol station construction at such sites is seldom explicitly forbidden.

In Finland the situation is somewhat obscure. There are few clear guidelines and standards of practice vary considerably across the country. Authorities in one region will approve petrol station projects in such areas while the authorities in another will reject them. This arbitrary situation even extends to projects which are identical in every respect.

The subject of petrol station construction in major catchment areas is somewhat controversial and arguments for and against the practice are keenly debated. Since there are many roads and built up areas in major groundwater catchment areas, many in Finland would argue that it should be possible, by applying modern technology, to construct petrol stations in these areas as well.

Current regulations in Finland do contain additional technological requirements which apply specifically to the design and execution of petrol station projects in such catchment areas. It is not the purpose here to investigate these requirements, but as might be expected, they are considerably more stringent than the regulations governing petrol station construction elsewhere in the country.

The lack of a consistent common uniform policy in Finland has also been responsible for much misunderstanding and confusion concerning the regulations in force. Indeed, there are currently several cases where permission to proceed with petrol station projects are being disputed in the courts, some in the Supreme Administrative Court and others in the Administrative Court. It is obviously in the interests of no party that permit applications result in legal dispute simply because the regulations lack clarity.

There are two main points worth noting in this context. First, a decision in principle should be made as to whether a petrol station construction project can or cannot proceed in a major groundwater area. Then, if approval is granted, it is necessary to reach agreement between all the parties involved as to the most appropriate technological solution available. According to existing legislation, it is possible to construct petrol stations in such areas and therefore it should also be a requirement to find an appropriate technological solution. However, as noted earlier, irrespective of regulations, every petrol station project is in some way unique. This might explain court decisions to shut down one existing station and refuse permits for new ones while subsequently granting permits to build petrol stations situated in major groundwater areas. This happened as recently as 2004.

The standard SFS 3352 [59] contains a technological solution for petrol station projects that are permitted in such catchments areas. According to this solution, the *“principal of double detention”* is to be applied. This involves the installation, wherever possible, of duplicate structures such as pipes, tanks, drainage and separators. The purpose of such a solution is to minimize the risk of harmful compounds escaping into the soil and water in the event of failure of the first wall or structure.

In principle such a requirement is to be welcomed. However, in certain respects it would not always guarantee environmental protection. In practice it is not possible to apply the “principle of double detention” in all cases such as in pipe work joints, for example.

According to the findings of this study, there are no technological solutions which would provide an absolute guarantee of the environmental safety of petrol station operations at sites in major groundwater areas. However, an additional method that could be employed is a solution which involves the ***total insulation of the surrounding underground environment***. This would employ the "principal of double detention", but with the added precaution of complete underground insulation. Such a solution would ensure that none of the ***petrol station's structures and equipment comes into contact with the natural surroundings.*** This type of insulation could, for example, be achieved using a composite structure, isolated vertically and horizontally, made of membrane, concrete and/or bentonite. This is one practical way to improve environment protection.

6.6 Guidelines for the Finnish oil industry

The following guidelines can be of use to all the parties involved in the Finnish oil industry. They should provide a useful source of information and advice for the authorities, oil company staff, contractors, designers and suppliers of materials.

6.6.1 2-wall tanks for new projects

In new petrol station projects it is recommended that installation of 2-wall tanks should be made a compulsory requirement in Finland. Irrespective of the obvious need for such a requirement in major groundwater catchment areas, this would ensure overall conformity to the principles of BAT. Indeed there are a number of oil companies in Finland whose policy it is to install only 2-wall tanks, even though this is not yet an official requirement.

6.6.2 Removal of 1-wall tanks from major groundwater catchment areas

There are still many 1-wall tanks located in major groundwater catchment areas throughout Finland and it is one of the recommendations of the present study that these should be taken out of service as early as possible.

6.6.3 Vapour recovery stage 2

The results of this study also suggest a need to make vapour recovery stage 2-systems legal requirements. Again, although this is not presently mandatory, a number of oil companies now equip their petrol stations with such systems. The practical field investigation revealed that the vapour recovery stage 2-system is already in use at some 40 % of Finnish Petrol stations.

6.6.4 Pavements at forecourts and fuel filling areas

There is a need for more specific guidelines as to the most suitable materials for use in the construction of forecourts and fuel filling areas. It has already been noted that in Germany, Hungary, Russia, Spain and United Kingdom asphalt is not approved for such purposes. Even the use of concrete or concrete bricks requires careful regulation in order to control the quality of construction and materials.

6.6.5 Underground spaces

In response to public concern over recent explosions at petrol station sites, there is clearly a need to change the regulations covering empty underground spaces beneath forecourt and fuel filling areas. None of the following alternative solutions can guarantee total safety. The first solution involves infilling such underground spaces with sand, mineral wool or other similar material. The danger of explosion will be prevented, or at least minimised, if oxygen is prevented from entering such spaces.

Another possible solution, the ventilation of underground spaces, is clearly unsatisfactory because fuel vapour is heavier than air and ventilation does not provide an effective extraction method. On the contrary, ventilation based on gravitation could make the mixture of air and vapour more volatile. This type of solution requires the support of a supplementary system to assist the expulsion of air from the underground space by incorporating additional ventilation equipment.

However, even such a solution would not be immune to failure from breakdown. Therefore, even this solution would require additional safety precautions.

Whatever the systems employed, the official requirements should be clear and comprehensible so that all parties in the oil industry understand which solutions are to be adopted in practice. As mentioned above, the ATEX-regulations [14, 16, 22] might help to improve the situation in the future.

6.6.6 Periodic inspection processes

In Finland there is currently no requirement to conduct a periodic inspection of fuel equipment and tanks, with the exception of 1-wall tanks at sites in major groundwater catchments areas. This is, however, a paradoxical state of affairs. As mentioned in Section 6.6.2, from an environmental standpoint the construction of 1-wall tanks should not be permitted anywhere.

The periodic inspection of all kinds of tank and fuel equipment including pipes, overfilling stop systems, tank chambers, vapour recovery systems, alarm systems and pavements should be made a legal requirement at all petrol stations. Such inspections could be carried out in much the same way as the fire authorities currently conduct their own periodic fire inspections.

In certain permit applications the regional and municipal authorities already require regular periodic inspection and continuous self-monitoring, despite the fact that this is not required under current legislation.

It should be mentioned in this context that a number of oil companies also make provision for conducting periodic inspections of underground storage tanks on their own initiative.

6.6.7 Authorization of designers and contractors

In petrol station projects, there are many instances of damage discovered not only during but also after the construction and installation process. Much of this is directly attributable to insufficient know-how and a lack of skilled manpower on the part of companies who themselves are often highly regarded civil engineers and plumbing contractors [29, 30, 31, 32]. Legislation and authorization could help to improve this situation. It is also worth noting that electrical contractors and oil-burner contractors, by contrast, are required by law to obtain licences for their trades. Perhaps such requirements should be mandatory in the oil industry as well.

Designers, contractors, individuals and companies working in and serving the oil industry, should be subject to validation by an official authorizing body. Much of the damage and many of the accidents which occur in the execution of petrol station projects could be prevented by monitoring professional practices. The demand for better training and qualifications for designers, contractors and fuel equipment installation companies is bound to have a positive impact on levels of environmental protection.

It may be argued that the authorization of professional skills runs counter to the principle of open competition. However, this does not diminish the real need for a means to monitor and guarantee the professional skills and expertise of key personnel in the field.

Because authorization of professional qualifications is not required under current legislation, a number of oil companies have, instead, devised their own systems for the accreditation of designers and contractors. In these cases, some oil companies make specific demands on contractors to have a Quality, Environment and Safety programme, for example. Such a system, while laudable, is also open to abuse, especially at the tendering stage. Quality and safety guarantees can be expensive to implement, leaving a contractor with a QES programme vulnerable to being undercut by one without such a programme.

6.6.8 National BAT-report

There is also a need to draw up a national BAT-report in Finland. As noted earlier, the standard SFS 3352 [59] or other technical regulations do not contain the technical requirements necessary to fulfil BAT-principles.

As minimum requirements the national BAT-report for petrol stations should include the following:

- 2-wall underground fuel storage tanks
- vapour recovery stage 2-systems
- suitable pavement materials for forecourts and fuel filling areas
- monitoring programmes.

In sum, this means installing only 2-wall tanks since these are much safer environmentally than 1-wall tanks. The petrol station should also be equipped with both stages (1 and 2) of vapour recovery systems. Only suitable pavement materials (not asphalt) should be used in the factitious compaction structures for the construction of forecourts and fuel filling areas. BAT should make it a standard requirement to implement continuous monitoring programmes for ensuring the proper functioning of the most critical equipment such as tanks, chambers, filling sumps, fuel pipes, overfilling prevention systems, dispensers, oil separators and alarm systems.

6.7 Further research

This study demonstrates the clear need for further research in this area. It is also hoped that it will provide the impetus for further development in the important area of environment protection. New approaches must be developed and alternative systems and operations must be tested out. Levels of environment protection can only be improved through experimentation and innovation.

There are a wide variety of risk analysis models used in the chemical industry which could be examined to see if they have any application to petrol stations. Risk and safety management are areas of growing importance and will play an ever increasing role in the oil industry, too.

Research into materials is also another fruitful area for study. The development of new materials and innovative applications for existing ones could have a significant impact on the manufacture of equipment and structures at petrol stations, making them more robust and chemical resistant to petrol and diesel oil. This would be of particular relevance to operations in major groundwater catchment areas.

In addition to these technological areas, there is also much scope for research into administrative practices. It would, for example, be interesting to know what it would mean in practical terms if there were only one single administrative body in the oil industry responsible for drafting legislation and running day-to-day operations. In addition, it would be useful to discover if such a body could also manage the practical matters of permit processing and the supervision of construction projects. Administrative research could also include a study of the attitudes and opinions of oil industry personnel towards the value of regular safety inspections and risk analysis.

There is also a growing acknowledgement within this sector of the oil industry of a need for greater international co-operation and research collaboration. Successful innovation and solutions discovered elsewhere should also be tried and tested in Finland.

It may appear that the above observations and recommendations for further research into improving environment protection at petrol stations are unattainable ideals. It is worth remembering, however, that without some degree of idealism it might not be possible to ensure a better world for future generations.

7. CONCLUSIONS

This study has investigated the environmental protection standards at petrol stations. The level of environmental protection level has been compared between Finland and the following nine European countries; Germany, Hungary, Lithuania, Norway, Poland, Russia, Spain, Sweden and United Kingdom.

In Section 1.13 at the beginning of the study, six research questions were posed. In the present Chapter the questions are presented again along with their answers. These form the main conclusions of this investigation.

How well are the objectives of the Environment Protection Act being fulfilled, especially those regulations for applying BAT in petrol station operations? The Finnish oil industry, including the oil companies, designers, contractors and public authorities, lacks a full appreciation of BAT. Since 2000 it has been a legal requirement that BAT should be adopted in each new petrol station project. However, in Finland there is not one case in which BAT principles have been mentioned in permit applications for new petrol station projects. This indicates an urgent need to draw up a national BAT-report to remedy the situation.

How effectively do the regulations and the operations of the various authorities influence the essential environmental impact? The results show that the present regulations and authorities’ operations are inadequate for protecting the environment. By issuing more stringent regulations to the oil industry and re-organising the responsibilities of authorities it should be possible to achieve more effective environment protection.

What is the level of environment protection and BAT in Finland compared with the selected European countries? The level of environment protection in Finland is much lower than it should be and was expected to be. Finnish protection standards at petrol stations are markedly lower than in Germany and Hungary and lower than in Lithuania, Poland, Spain and United Kingdom. It is similar to Sweden and higher than in Norway and Russia. Since these countries provide a representative cross-section of levels of environmental protection at petrol stations across Europe, it must be concluded that standards in Finland are lower than in Europe as a whole. BAT itself was not compared but, based on the results of environment protection, it is possible to conclude that BAT receives more recognition in those countries where the environment protection level is higher than in Finland.

How far can environment protection be made more effective by the oil companies themselves through the development of legislation and permit procedures and also by follow-up monitoring? Environment protection levels could be significantly improved if the oil-companies themselves started to draw up procedures for risk analysis, monitoring programmes and periodic inspections. This could be initiated without the need for decrees from external sources such as the authorities or laws and regulations.

How accurately does risk analysis describe the essential and harmful impacts on the environment? Risk analysis is both an excellent tool and method for describing the essential and harmful impact on the environment from petrol stations.

Which are the crucial factors to be included in BAT for petrol stations? At minimum, BAT for petrol stations should include the following crucial factors as mandatory requirements; 2-wall underground fuel storage tanks instead of 1-wall tanks, both vapour recovery stage 1- and 2-systems, suitable pavement materials for forecourts and fuel filling areas and monitoring programmes of critical functions, structures and equipment which form the source of possible releases to the environment.

In addition to the above findings, this study has also reached a number of theoretical conclusions. The research method adopted here involved a combination of survey and observation approaches that, together with an examination of administration, legislation, regulations and permission procedures, constitute a further outcome of this study. The method ensures reliable and verifiable results, especially because of the double-checking involved. However, the method itself was seen as being rather laborious to apply. Nonetheless, it can be applied in other industrial fields, though the risk analysis will need to be performed individually for each case. The checklist devised for the practical field investigation can also be used as a tool for supervision.

Despite the fact that the standard Flammable Liquids Service Stations SFS 3352 4th edition [59] was published as recently as 2004, it now needs to be updated without delay. The standard SFS 3352 includes too many omissions and does not warrant the status of a BAT reference document.

Because the results show such low levels of environmental protection at petrol stations in Finland, a number of practical guidelines are given here to help remedy the situation. There is a need to improve the administrative practices of the relevant public authorities as well as clarifying their roles and responsibilities in regulating and supervising operations at petrol stations across the country. The introduction of regular periodic inspections and continuous monitoring of petrol station activities would also help in raising protection standards. Designers and contractors should be required to obtain official validation of their professional skills and companies should also be required to demonstrate their competence to undertake petrol station projects.

Legislation should clearly stipulate the specifications for paving materials used in forecourts and fuel filling areas. In addition, similar legislation is required to cover the underground spaces of forecourts and fuel filling areas in order to raise standards in general and prevent explosions in particular. It is recommended that only 2-wall storage tanks be installed in new projects and all existing 1-wall tanks be removed from sites in major groundwater areas. Furthermore, every petrol station should be equipped with a vapour recovery stage 2-system.

It is believed here that the implementation of the above recommendations will considerably raise levels of environmental protection at Finnish petrol stations from being some of the worst to at least comparable with the best in Europe.

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APPENDICES

APPENDIX 1

Major Environmental Risks and Release Sources at Petrol Stations (to air, soil and water)

3 pages

"Environmental Protection Standards at Petrol Stations: A Comparative Study between Finland and Selected European Countries"

Major Environmental Risks and Release Sources at Petrol Stations (to air, soil and water)

	Risk or/and release source	Consequence of risk	Recommended action to limit environmental damage.
1.	Wall of underground tank broken.	Fuel product gets into soil and groundwater → Contamination	1.1 2-wall storage tanks. 1.2 Factitious compaction structure around tanks. 1.3 Real time gauging system. 1.4 Real time alarm system. 1.5 Periodic inspections of tanks and control programme.
2.	Underground pipes leak between the dispenser sump and tank chamber.	Fuel product enters soil and groundwater → Contamination	2.1 2-wall petrol pipes. 2.2 Factitious compaction structure around pipes. 2.3 Periodic inspections of pipes and monitoring programme.
3.	Underground pipes leak inside unsealed chamber.	Fuel product enters soil and groundwater → Contamination (Danger of explosion.)	3.1 Sealed chambers. 3.2 Real time alarm system. 3.3 Periodic inspections and monitoring programme for pipes and chambers. 3.4 (Filling chambers; e.g. with sand or mineral wool).
4.	Underground pipes leak beneath dispenser.	Fuel product enters soil and groundwater → Contamination (Possible danger of explosion if there are empty spaces beneath pump island or dispenser.)	4.1 Factitious compaction structure under the forecourt. Pipe installation on the membrane. 4.2 Sealed sumps. 4.3 Periodic inspections and monitoring programme for pipes, dispensers and sumps. 4.4 (Filling empty spaces and/or sump; e.g. with sand or mineral wool).
5.	Dispenser leaks from hydraulic sections.	Fuel product enters soil and groundwater → Contamination	5.1 Factitious compaction structure under forecourt. 5.2 Sealed sumps. 5.3 Oil-proof pavement to the forecourt. 5.4 Forecourt rainwater drainage to oil separator. 5.5 Periodic inspections and monitoring programme for the dispenser.

6.	Overflow when filling storage tank.	Fuel product enters soil and groundwater → Contamination	6.1 Overfill prevention. 6.2 Filling wells. 6.3 Oil-proof pavement to the fuel filling area. 6.4 Filling area's rainwater drainage to oil separator. 6.5 Factitious compaction structure under fuel filling area.
7.	Overflow when filling customers' vehicles.	Fuel product enters soil and groundwater → Contamination	7.1 Oil-proof pavement to the fuel filling area. 7.2 Forecourt rainwater drainage to oil separator. 7.3 Factitious compaction structure under forecourt.
8.	Pavement of fuel filling area is not oil-proof.	Fuel product enters soil and groundwater → Contamination	8.1 Oil-proof pavement to the fuel filling area. 8.2 Factitious compaction structure under fuel filling area. 8.3 Periodic inspections and monitoring programme for the pavement.
9.	Pavement of the forecourt is not oil-proof.	Fuel product enters soil and groundwater → Contamination	9.1 Oil-proof pavement to the forecourt. 9.2 Factitious compaction structure under forecourt. 9.3 Periodic inspections and monitoring programme for the pavement.
10.	No drainage system and oil separator at fuel filling area.	Fuel product enters soil and groundwater → Contamination	10.1 Construction of drainage system. 10.2 Installation of oil separator.
11.	No drainage system and oil separator at forecourt	Fuel product enters soil and groundwater → Contamination	11.1 Construction of drainage system.. 11.2 Installation of oil separator.
12.	Absence of overflow prevention.	Overflow when filling the storage tank → Fuel product enters soil and groundwater → Contamination	12.1 Installation of overflow prevention. 12.2 Periodic inspections and monitoring programme for overflow prevention equipment. Oil-proof pavement to the fuel filling area. 12.3 Factitious compaction structure under the fuel filling area.
13.	Absence of filling sump.	Spillage when filling storage tank → Fuel product enters soil and groundwater → Contamination	13.1 Installation of filling sump. 13.2 Periodic inspections and monitoring programme for filling sump. 13.3 Oil-proof pavement to the fuel filling area. 13.4 Factitious compaction structure under fuel filling area.

14.	Empty underground spaces beneath the forecourt	Spillage when filling customers' vehicles → petrol vapour enters empty spaces → Danger of explosion	14.1 Elimination of empty spaces under forecourt. 14.2 Filling all empty spaces; e.g. with sand or mineral wool. 14.3 Periodic inspections and monitoring programme.
15.	Underground spaces beneath the filling area	Splashes when filling storage tank → petrol vapour enters empty spaces → Danger of explosion	15.1 Elimination of empty spaces under filling area. 15.2 Filling all spaces; e.g. with sand or mineral wool. 15.3 Periodic inspections and monitoring programme.
16.	Lack of vapour recovery stage 1-system (or totally non-existent)	Vapour enters air → Pollution Vapour enters underground spaces → Danger of explosion	16.1 Installation of vapour recovery stage 1-system. 16.2 Periodic inspections and monitoring programme.
17.	Lack of vapour recovery stage 2-system (or totally non-existent)	Vapour enters air → Pollution Vapour enters underground spaces → Danger of explosion	17.1 Installation of vapour recovery stage 2-system. 17.2 Periodic inspections and monitoring programme.
18.	Non-functioning alarm system.	Petrol enters drainage → Danger of explosion	18.1 Periodic inspections and monitoring programme.
19.	General damage to equipment	All the abovementioned risks.	19.1 Periodic inspections and monitoring programme.

NOTE

The above do not constitute a complete list of the risk factors which exist at petrol station premises. However, they do provide a working framework for risk assessment and preventative action.

In planning risk assessment for a specific petrol station, each stage must be planned systematically according to risk assessment theory. Each risk must be evaluated in terms of probability and significance before the final risk level is determined and the final decisions are made.

APPENDIX 2

Questionnaire to Oil Industry Professionals in Selected European Countries

8 pages

"**Environmental Protection Standards at Petrol Stations: A Comparative Study between Finland and Selected European Countries**"

QUESTIONNAIRE TO THE DOCTORAL THESIS

Please answer “Yes” or “No” to the following questions where possible.

Question 1 Is it permitted under your country’s legislation to construct a petrol station with 1-wall underground storage tanks?

Answer:

Question 2 Is there any legal requirement in your country to conduct periodic inspections of 1-wall underground storage tanks?

Answer:

Question 3 Is there any legal requirement in your country to conduct periodic inspections of 2-wall underground storage tanks?

Answer:

Question 4 Are there any major groundwater catchment areas in your country?

Answer:

Question 5 If there are major groundwater catchment areas in your country, is it permitted to construct a petrol station in such areas?

Answer:

Question 6 If an existing petrol station is located on an important groundwater catchment area, is it permitted to have single wall underground storage tanks?

Answer:

Question 7 Is it permitted under you country's legislation to construct petrol stations having 1-wall petrol pipes (suction and filling pipes)?

Answer:

Question 8 Is it a requirement under your country's legislation to conduct periodic inspections of petrol pipes?

Answer:

Question 9 Is it a requirement under your country's legislation to install a monitoring well for checking the soil in the area surrounding underground tanks?

Answer:

Question 10 Is it a requirement under your country's legislation to build a factitious compaction structure (e.g. made of HDPE-membrane or bentonite) under and around the underground tanks?

Answer:

Question 11 Is it a requirement under your country's legislation to sewer rainwater from the forecourt to the oil separator?

Answer:

Question 12 Is it a requirement under your country's legislation to sewer rainwater from the fuel filling area to the oil separator?

Answer:

Question 13 Is there any requirement under your country's legislation to conduct periodic inspections of drainage equipment (pipes, wells, etc.)?

Answer:

Question 14 Under legislation in your country, is it permitted to sewer rain water from the forecourt and fuel filling area after discharging the oil separator's contents (e.g. to an open ditch)?

Answer:

Question 15 Is it permitted under your country's legislation to construct forecourt pavement areas using concrete bricks?

Answer:

Question 16 Is it permitted under your country's legislation to construct forecourt pavement areas using concrete?

Answer:

Question 17 Is it permitted under your country's legislation to construct forecourt pavement areas using asphalt?

Answer:

Question 18 Is it permitted under legislation in your country to construct the pavement of fuel filling areas using concrete bricks?

Answer:

Question 19 Is it permitted under your country's legislation to construct the pavement of fuel filling areas using concrete?

Answer:

Question 20 Is it permitted under your country's legislation to construct the pavement of fuel filling areas using asphalt?

Answer:

Question 21 Is it required under your country's legislation to construct a factitious compaction structure (e.g. made of HDPE-membrane or bentonite) under forecourt pavements?

Answer:

Question 22 Is it required under your country's legislation to construct a factitious compaction structure (e.g. made of HDPE-membrane or bentonite) under the pavement of fuel filling areas?

Answer:

Question 23 Is it required under your country's legislation to make provision for tanker truck breakdowns on petrol station premises?

Answer:

Question 24 Is it required under your country's legislation to equip petrol stations with an overfill prevention system?

Answer:

Question 25 Is it required under your country's legislation to equip petrol stations with a vapour recovery stage 1-system?

Answer:

Question 26 Is it required under your country's legislation to equip petrol stations with a vapour recovery stage 2-system?

Answer:

Question 27 Is it required under your country's legislation to equip underground tanks with a chamber (sump, manhole, maintenance well)?

Answer:

Question 28 Is it required under your country's legislation to ensure that an underground tank's chamber is sealed tight?

Answer:

Question 29 Is it required under your country's legislation that the interface between the dispenser (bottom of dispenser or sump under the island) and the ground is sealed tight?

Answer:

Question 30 Is it required under your country's legislation to equip the filling pipe with a filling sump or such device to prevent splashed fuel seeping into the ground?

Answer:

Question 31 Is it required under your country's legislation to use 2-wall petrol pipes?

Answer:

Question 32 Is it required under your country's legislation to construct a factitious compaction structure (e.g. made of HDPE-membrane or bentonite) beneath and around underground petrol piping?

Answer:

Question 33 Is it permitted under your country's legislation to have underground spaces (chambers, sumps, channels, etc.) beneath the forecourt (making it possible for petrol vapour to reach such areas)?

Answer:

Question 34 Is it permitted under your country's legislation to have underground spaces (chambers, sumps, channels, etc.) beneath fuel filling areas (making it possible for petrol vapour to reach such areas)?

Answer:

Question 35 Is there any mention in your country's legislation of a legal minimum distance between the filling pipe and the dispenser?

Answer:

Question 36 Is it permitted under your country's legislation to install the filling pipe at the pump island?

Answer:

Question 37 Is it required under your country's legislation to equip petrol stations with a gauging system (an electronic fuel level control system)?

Answer:

Question 38 Is it sufficient under your country's legislation to fulfil the fuel level control system requirements manually by means of a dipstick (i.e. staff using a measuring rod)?

Answer:

Question 39 In addition to having an electronic gauging system, is it also a requirement under your country's legislation to have a dipstick system?

Answer:

Question 40 Is it a requirement under your country's legislation to keep a service manual at petrol stations and to ensure that all fuel equipment has a control programme?

Answer:

Question 41 Is it a requirement under your country's legislation to install automatic fire alarm systems at petrol stations?

Answer:

Question 42 Is it a requirement under you country's legislation to install automatic vandal alarm systems at petrol stations?

Answer:

Question 43 Is it a requirement under your country's legislation to install oil separator alarm systems at petrol stations?

Answer:

Question 44 Is it required under your country's legislation that petrol stations be equipped with leak detection systems (automatic alarms) for 2-wall storage tanks (controlling the space between 2 walls)?

Answer:

APPENDIX 3

Summary of the Answers to the Questions Shown in Appendix 2

3 pages

Question	Answers								
	FIN	GER	HUN	LT	NOR	PL	RUS	SP	SWE	UK
1	YES	NO	NO	YES	YES	NO	YES[1]	YES[2]	YES	NO
2	NO[3]	YES[4]	NO[5]	YES	YES	YES	YES	YES	YES	YES
3	NO	YES	YES	YES	NO	YES	YES	YES	YES	NO
4	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
5	YES[6]	YES[7]	NO[8]	NO	YES	YES[7]	YES	YES	YES	YES
6	YES	NO	NO	NO	NO	NO	YES	YES	YES	NO
7	YES	NO[9]	NO[9]	YES	YES	YES	YES	YES	YES	NO[9]
8	NO	YES	NO	NO	NO	Y/N	YES	YES	NO	Y/N
9	NO	NO	NO	YES[10]	NO	Y/N	YES[10]	Y/N	NO	YES
10	NO	NO	NO	YES[10]	NO	NO	YES[10]	NO	NO	NO
11	YES	YES	YES	YES	YES[11]	YES	YES	YES	YES[11]	YES
12	YES	YES	YES	YES	NO	YES	YES	YES	YES[11]	YES
13	YES[12]	YES	YES[12]	NO	NO	YES[12]	YES	YES	NO	NO
14	YES	Y/N	YES	YES	YES	YES	YES	NO	Y/N	Y/N
15	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]
16	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
17	YES	YES[14]	NO	YES[15]	YES	YES[15]	YES	NO	YES	NO
18	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	YES[13]	NO
19	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
20	YES	YES[14]	NO	YES[14]	YES	YES[14]	NO	NO	YES	NO
21	NO[16]	NO[17]	YES	YES	NO	YES[18]	YES	NO	NO	NO
22	NO[16]	NO[17]	YES	YES	NO	YES[18]	YES	NO	NO	NO
23	Y/N	Y/N	Y/N	Y/N		Y/N	YES	YES	Y/N	Y/N
24	YES	YES	YES	YES	NO[19]	YES	YES	YES	YES	YES
25	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
26	NO	YES	YES	YES	NO	YES	Y/N	NO	YES	NO
27	YES	YES	YES	YES	NO	YES	YES	YES	NO	YES
28	NO	YES	YES	NO	NO	YES	YES	YES	YES[20]	YES
29	YES	YES	YES	NO	Y/N	YES	YES	YES	YES	YES
30	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
31	NO	YES[21]	YES[21]	NO	NO	NO	NO	NO	NO	YES[21]
32	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
33	YES[22]	NO	NO	YES	YES	Y/N	NO	Y/N	NO	YES
34	YES[22]	NO	NO	YES	YES	Y/N	Y/N	Y/N	NO	YES
35	NO	NO	Y/N	NO	YES	YES	Y/N	NO	Y/N	NO
36	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES
37	NO	Y/N	Y/N	NO	NO	Y/N	YES	NO	Y/N	Y/N
38	YES	Y/N	Y/N	YES	YES	YES	Y/N	YES	YES	Y/N
39	Y/N	NO	YES	NO	NO	Y/N	YES	Y/N	YES	Y/N
40	YES[23]	Y/N	Y/N	NO	YES	Y/N	YES	Y/N	YES	YES
41	NO	Y/N	Y/N	NO	NO	Y/N	YES	Y/N	NO	Y/N
42	NO	NO	Y/N	NO	NO	NO	NO	NO	NO	Y/N
43	Y/N	NO	Y/N	NO	Y/N	NO	Y/N	Y/N	YES	YES
44	Y/N	YES	YES	YES	Y/N	Y/N	Y/N	YES	Y/n	YES

YES[1]	=	Only if certain additional requirements are fulfilled.
YES[2]	=	Yes, but only if 1-wall tanks will be installed in a concrete bunker (=2-wall).
NO[3]	=	1-wall tanks are only inspected if they are located in major groundwater catchment areas.
YES[4]	=	Only applicable to older existing tanks.
NO[5]	=	In Hungary 1-skin tanks should not exist at all.
YES[6]	=	In some regions of Finland it is possible. Sometimes the authorities have not accepted it.
YES[7]	=	It is possible but will be difficult and expensive because of special requirements within permission process.
NO[8]	=	It should not be possible but there are some cases where it has been accepted for significant reasons.
NO[9]	=	In Germany, Hungary and United Kingdom filling pipes (and pressure pipes) are always required to be 2-wall.
YES[10]	=	In Lithuania and Russia this applies to 1-wall tanks.
YES[11]	=	In Norway and Sweden this requirement is applicable to old stations; hence the use of red.
YES[12]	=	Applicable to oil separators (and other separators), but not to other drainage systems.
YES[13]	=	In each country the use of concrete bricks is permitted as a forecourt paving material. It is also a requirement in every country to use some form of oil-proof sealant.
YES[14]	=	Asphalt itself it not enough. If asphalt is used, it must be a certified pavement system and/or a factitious compaction structure is needed.
YES[15]	=	In case it is possible to find oil-proof asphalt. Difficult in practise.
NO[16]	=	No, only if the pavement is made of concrete bricks or normal asphalt.
NO[17]	=	No, the pavement itself must be dense and oil-proof.
YES[18]	=	Yes, if this is the only way to ensure the density prevents harmful compounds seeping into the ground.

NO[19] = Not required by law in Norway but normally installed in practice.

YES[20] = Yes, if a sump is installed. In such cases it must be sealed or filled with sand or mineral wool or other such materials.

YES[21] = In Germany, Hungary and United Kingdom filling pipes (and pressure pipes) are always required to be 2-wall.

YES[22] = Only if there is ventilation.

YES[23] = Where the petrol station is located in major ground water catchment area.

APPENDIX 4

Field Investigation Checklist

2 pages

"Environmental Protection Standards at Petrol Stations: A Comparative Study between Finland and Selected European Countries"

Field Investigation Checklist

Country ____________________________ Date ______________

City/Town ____________________________

Station ____

____

____

The following questions refer to the facilities and equipment at the petrol station

1. Is there drainage of the forecourt?

Yes _____________

No _____________

----

2. Is there drainage of the fuel filling area?

Yes _____________

No _____________

----

3. What is the composition of pavement of the forecourt?

Asphalt ____________

Concrete ____________

Concrete stone ____________

----

4. What is the composition of pavement of the fuel filling area?

Asphalt ____________

Concrete ____________

Concrete stone ____________

----

5. Is the vapour recovery system 1-stage?

Yes ____________

No ____________

----

6. Is the vapour recovery system 2-stage?

Yes ____________

No ____________

----

7. Are there tank chambers?

Yes ____________

No ____________

----

8. Are there filling pipe sumps or other kinds of basin?

Yes ____________

No ____________

APPENDIX 5

Results of the Practical Field Investigation

8 pages

Finland	Stations	Yes	No	%
Vapour recovery stage 1	409	405	4	99
Vapour recovery stage 2	409	162	247	40
Forecourt drainage	409	405	4	99
Filling area drainage	409	389	20	95
Tank chambers	409	409		100
Filling sumps	409	404	5	99

Germany	Stations	Yes	No	%
Vapour recovery stage 1	37	37		100
Vapour recovery stage 2	37	37		100
Forecourt drainage	37	37		100
Filling area drainage	37	37		100
Tank chambers	37	37		100
Filling sumps	37	37		100

Hungary	Stations	Yes	No	%
Vapour recovery stage 1	59	59		100
Vapour recovery stage 2	59	58	1	98
Forecourt drainage	59	59		100
Filling area drainage	59	59		100
Tank chambers	59	59		100
Filling sumps	59	59		100

Lithuania	Stations	Yes	No	%
Vapour recovery stage 1	68	65	3	96
Vapour recovery stage 2	68	63	5	93
Forecourt drainage	68	67	1	99
Filling area drainage	68	66	2	97
Tank chambers	68	68		100
Filling sumps	68	68		100

Norway	Stations	Yes	No	%
Vapour recovery stage 1	62	62		100
Vapour recovery stage 2	62	2	60	3
Forecourt drainage	62	12	50	19
Filling area drainage	62	7	55	11
Tank chambers	62	62		100
Filling sumps	62	62	2	97

Poland	Stations	Yes	No	%
Vapour recovery stage 1	73	66	7	90
Vapour recovery stage 2	73	51	22	70
Forecourt drainage	73	70	3	96
Filling area drainage	73	70	3	96
Tank chambers	73	73		100
Filling sumps	73	73		100

Russia	Stations	Yes	No	%
Vapour recovery stage 1	50	24	26	48
Vapour recovery stage 2	50	15	35	30
Forecourt drainage	50	47	3	94
Filling area drainage	50	37	13	74
Tank chambers	50	50		100
Filling sumps	50	47	3	94

Spain	Stations	Yes	No	%
Vapour recovery stage 1	79	79		100
Vapour recovery stage 2	79	3	79	4
Forecourt drainage	79	78	1	99
Filling area drainage	79	76	3	96
Tank chambers	79	79		100
Filling sumps	79	79		97

Sweden	Stations	Yes	No	%
Vapour recovery stage 1	92	92		100
Vapour recovery stage 2	92	92		100
Forecourt drainage	92	56	36	61
Filling area drainage	92	34	58	37
Tank chambers	92	19	73	21
Filling sumps	92	76	16	83

United Kingdom	Stations	Yes	No	%
Vapour recovery stage 1	64	64		100
Vapour recovery stage 2	64	4		6
Forecourt drainage	64	64		100
Filling area drainage	64	64		100
Tank chambers	64	64		100
Filling sumps	64	64		100

Finland, total 409 petrol stations						
Forecourt pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
106	13	253	23	12	1	1
26 %	3 %	62 %	6 %	3 %	0 %	0 %

Germany, total 37 petrol stations						
Forecourt pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
0	37 (10)	0	0	0	0	0
0 %	100 %	0 %	0 %	0 %	0 %	0 %

Hungary, total 59 petrol stations						
Forecourt pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
0	12	47	0	0	0	0
0 %	20 %	80 %	0 %	0 %	0 %	0 %

Lithuania, total 68 petrol stations						
Forecourt pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
0	5	63	0	0	0	0
0 %	7 %	93 %	0 %	0 %	0 %	0 %

Norway, total 62 petrol stations						
Forecourt pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
13	3	38	2	6	0	0
21 %	5 %	61 %	3 %	10 %	0 %	0 %

Poland, total 73 petrol stations						
Forecourt pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
2	18	51	0	2	0	0
3 %	25 %	70 %	0 %	3 %	0 %	0 %

Russia, total 50 petrol stations						
Forecourt pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
1	3	44	0	2	0	0
2 %	6 %	88 %	0 %	4 %	0 %	0 %

Spain, total 79 petrol stations						
Forecourt pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
1	70	6	0	1	1	0
1 %	89 %	8 %	0 %	1 %	1 %	0 %

Sweden, total 92 petrol stations						
Forecourt pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
28	9	43	5	3	4	0
30 %	10 %	47 %	5 %	3 %	4 %	0 %

United Kingdom, total 64 petrol stations						
Forecourt pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
0	38	26	0	0	0	0
0 %	60 %	40 %	0 %	0 %	0 %	0 %

Finland, total 409 petrol stations						
Fuel filling area's pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
218	104	52	18	13	0	8
53 %	25 %	13 %	4 %	3 %	0 %	2 %

Germany, total 37 petrol stations						
Fuel filling area's pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
0	37 (5)	0	0	0	0	0
0 %	100 %	0 %	0 %	0 %	0 %	0 %

Hungary, total 59 petrol stations						
Fuel filling area's pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
0	16	40	0	0	3	0
0 %	27 %	68 %	0 %	0 %	5 %	0 %

Lithuania, total 68 petrol stations						
Fuel filling area's pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
2	22	44	0	0	0	0
3 %	32 %	65 %	0 %	0 %	0 %	0 %

Norway, total 62 petrol stations						
Fuel filling area's pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
38	2	5	2	4	0	13
61 %	3 %	8 %	3 %	6 %	0 %	21 %

Poland, total 73 petrol stations						
Fuel filling area's pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
2	19	46	2	1	1	4
3 %	26 %	63 %	3 %	1 %	1 %	5 %

Russia, total 50 petrol stations						
Fuel filling area's pavements						
Asphalt	Concrete	Concrete Brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
1	11	21	0	3	6	8
2 %	22 %	42 %	0 %	6 %	12 %	16 %

Spain, total 79 petrol stations						
Fuel filling area's pavements						
Asphalt	Concrete	Concrete Brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
3	71	3	0	1	1	0
4 %	90 %	4 %	0 %	1 %	1 %	0 %

Sweden, total 92 petrol stations						
Fuel filling area's pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
65	13	6	5	1	2	0
71 %	16 %	7 %	5 %	1 %	2 %	0 %

United Kingdom, total 64 petrol stations						
Fuel filling area's pavements						
Asphalt	Concrete	Concrete brick	Asphalt + Concrete	Asphalt + Conc. brick	Concrete + Conc. brick	Partly Gravel/Grass
0	60	4	0	0	0	0
0 %	94 %	6 %	0 %	0 %	0 %	0 %

APPENDIX 6

Summary of the Petrol Stations Visited in Each Country during the Practical Field Research

2 pages

Finland	
Oil Company	**Amount of stations**
Neste	124
Teboil	59
ABC	48
Shell	48
ST1	46
Esso	38
JET	19
SEO	18
Ritoil	2
SUPA	2
95	2
Others	3
	409

Hungary	
Oil Company	**Amount of stations**
MOL	15
OMV	11
Shell	9
Esso	7
Agip	7
JET	3
Klub Petrol	2
Tesco	2
Others	3
	59

Norway	
Oil Company	**Amount of stations**
Shell	20
Statoil	14
Hydro Texaco	14
Esso	12
Others	2
	62

Germany	
Oil Company	**Amount of stations**
Aral	14
Esso	6
Shell	6
Agip	4
Total	3
Others	4
	37

Lithuania	
Oil Company	**Amount of stations**
Neste	23
Statoil	12
Lukoil	9
Uno-X	5
Ventus Nafta	4
EMSI	2
Others	13
	68

Poland	
Oil Company	**Amount of stations**
PKN Orlen	30
Neste	13
Rafineria Gdanska	7
Statoil	6
BP	3
JET	3
SHELL	3
Lotos	2
Others	7
	74

Russia	
Oil Company	**Amount of stations**
Neste	12
Balt-Trade	7
Slavneft	5
PTK	4
Aris	3
Faeton	3
Jukos	3
Lukoil	2
Shell	2
Tatneft	2
Others	7
	50

Spain	
Oil Company	**Amount of stations**
Repsol	14
Cepsa	13
BP	8
Campsa	7
Petrocat	7
Agip	5
Total	5
Esso	3
Shell	3
ERG	2
Esclatoil	2
Others	10
	62

Sweden	
Oil Company	**Amount of stations**
OKQ8	33
Statoil	20
Shell	13
Preem	7
Hydro	6
JET	4
Bilisten	3
Unox-X	2
Others	4
	92

United Kingdom	
Oil Company	**Amount of stations**
BP	21
Esso	14
Shell	14
Total	7
Tesco	4
Others	4
	64

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