Contents

Abstract i
Declaration ii
Published Papers iii
Acknowledgements iv
Contents v
List of Figures xi
List of Plates xvii
List of Tables xviii
Notation xxii
Abbreviations xxiv

Chapter 1 Introduction

1.1 The Need for Risk Management 1
1.2 The Need for Continued Research 5
1.3 Definition of ‘Risk’ and ‘Risk Management’ 7
  1.3.1 Risk 7
  1.3.2 Risk Management 8
1.4 Programmatic History of Risk Management 9
1.5 Outline of Following Chapters 14

Chapter 2 Literature Survey

2.1 The Five Steps of Risk Management 17
2.2 Risk Analysis: Identification 20
  2.2.1 Individual Consultation 23
  2.2.2 Group Discussion 24
  2.2.3 HAZOP 25
2.3 Risk Analysis Techniques: Estimation Stage 27
  2.3.1 Qualitative analysis 28
2.3.1.1 Fuzzy set analysis
2.3.1.2 Interviewing and Brain-storming
2.3.1.3 Personal and Corporate experience
2.3.1.4 Engineering judgement
2.3.2 Quantitative analysis
  2.3.2.1 Expected monetary value (EMV)
  2.3.2.2 Expected net present value (ENPV)
  2.3.2.3 Decision analysis
    2.3.2.3.a Algorithms
    2.3.2.3.b Decision matrix
    2.3.2.3.c Decision trees
    2.3.2.3.d Bayesian analysis
    2.3.2.3.e Stochastic decision tree
  2.3.2.4 Sensitivity analysis
    2.3.2.4.a Break-even analysis
    2.3.2.4.b Spiderplots
    2.3.2.4.c Scenario analysis
  2.3.2.5 EMV using Delphi peer group
  2.3.2.6 Risk adjusted discount rate (RADR)
  2.3.2.7 De Minimis theory
  2.3.2.8 Simulation
    2.3.2.8.a Monte Carlo sampling
    2.3.2.8.b Latin Hypercube technique
  2.3.2.9 Portfolio theory
2.3.3 Stochastic dominance
2.3.4 Summary
2.4 Risk Evaluation Stage
2.5 Risk Response Strategy
  2.5.1 Risk avoidance
  2.5.2 Risk transfer
  2.5.3 Risk retention
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5.4 Risk reduction</td>
<td>83</td>
</tr>
<tr>
<td>2.5.5 Other methods of handling risks</td>
<td>84</td>
</tr>
<tr>
<td>2.5.5.1 Risk spreading or diversification</td>
<td>84</td>
</tr>
<tr>
<td>2.5.5.2 Reducing risk liability by use of the employment contract</td>
<td>84</td>
</tr>
<tr>
<td>2.6 Risk Monitoring Stage</td>
<td>85</td>
</tr>
<tr>
<td>Chapter 3 Questionnaire on Risk Management</td>
<td></td>
</tr>
<tr>
<td>3.1 Introduction: The Need for a Risk Management Questionnaire</td>
<td>87</td>
</tr>
<tr>
<td>3.2 Design of the Questionnaire</td>
<td>88</td>
</tr>
<tr>
<td>3.3 Methodology of the Questionnaire</td>
<td>91</td>
</tr>
<tr>
<td>3.4 Format of the Questionnaire</td>
<td>92</td>
</tr>
<tr>
<td>3.5 Answering Techniques</td>
<td>93</td>
</tr>
<tr>
<td>3.6 Non-Response Replies</td>
<td>95</td>
</tr>
<tr>
<td>3.7 Summary of the Replies</td>
<td>97</td>
</tr>
<tr>
<td>Chapter 4 Analysis of the RMQ</td>
<td></td>
</tr>
<tr>
<td>4.1 Introduction</td>
<td>99</td>
</tr>
<tr>
<td>4.2 Analysis of Section 1 of the Questionnaire:</td>
<td>100</td>
</tr>
<tr>
<td>4.2.1 Analysis of primary responsibility of the respondents</td>
<td>100</td>
</tr>
<tr>
<td>4.2.2 Analysis of age and experience against job responsibility</td>
<td>102</td>
</tr>
<tr>
<td>4.3 Analysis of section 2 of the Questionnaire</td>
<td>107</td>
</tr>
<tr>
<td>4.3.1 Analysing and summarising questions 4 to 19 inclusive</td>
<td>107</td>
</tr>
<tr>
<td>4.3.1.1 Analysis of certain aspects of the respondents’ company</td>
<td>108</td>
</tr>
<tr>
<td>4.3.1.2 Analysing whether the physical conditions lead to accidents at work</td>
<td>109</td>
</tr>
<tr>
<td>4.3.1.3 Analysing some general questions on risk and risk management</td>
<td>110</td>
</tr>
<tr>
<td>4.3.1.4 Analysing some company approaches and methods</td>
<td>113</td>
</tr>
<tr>
<td>4.3.1.5 Analysing some personal characteristics of risk analysts</td>
<td>116</td>
</tr>
<tr>
<td>4.3.1.6 Analysing some general risk scenarios</td>
<td>119</td>
</tr>
<tr>
<td>4.3.1.7 Analysing some traits of different bodies of people</td>
<td>120</td>
</tr>
<tr>
<td>4.3.2 Company policies when responding to risk</td>
<td>122</td>
</tr>
</tbody>
</table>
4.4 Analysis of Section 3 of the Questionnaire

4.4.1 Analysing the methods of risk transfer
4.4.2 Analysing the methods used for financially transferring risks
4.4.3 Analysing the financial limits of insurance
4.4.4 Analysing the additional provisions the insurers provide and the value of those provisions
4.4.5 Analysing the proportion of replies who have ‘shared’ a risk, and the methods used to so do
4.4.6 Analysing the popularity and rationalism for using captive insurance companies

4.5 Analysis of Section 4 of the Questionnaire

4.5.1 Analysing the type of retained risks
4.5.2 Analysing some of the reasons for retaining risks
4.5.3 Analysing the frequency of the methods used to finance retained risks

4.6 Analysis of Section 5 of the Questionnaire

4.6.1 Analysing company’s competency at specific practices used for reducing risks
4.6.2 Analysing the methods successfully used to reduce accidents, i.e. risk

4.7 Analysis of Section 6 of the Questionnaire

4.7.1 Analysing the cost, as a fraction of the total project cost, of Risk Analysis compared to the Management of the Project.
4.7.2 Analysing financial losses through unforeseen risks
4.7.3 Analysing the prevalent techniques used for risk analysis
4.7.4 Analysing the company’s and respondent’s attitudes towards accidents and ‘acceptable risk’

4.8 Analysis of Section 7 of the Questionnaire

4.8.1 Analysing at which stage risk analysis is used during a project
4.8.2 Analysing the importance of six types of risk
4.8.3 Analysing the characteristics of some encountered risks
4.8.4 Identifying especially unusual or well analysed risks
Chapter 5  Risk Analysis Techniques used by AHL in comparison to other Oil Companies

5.1  Risk Analysis Techniques used by AHL

5.1.1 Introduction

5.1.2 The type of techniques used. (Qualitative, Quantitative, or a combination of the two)

5.1.3 An analysis of the risk analysis techniques used by the oil industry, AHL and company Y

5.2 Concluding remarks

Chapter 6  Case Study: AH001 Installation QRA

6.1 Introduction

6.2 Origination of the ‘Safety Case’

6.3 Brief overview of the AH001 installation

6.4 Risk Analysis Procedure as Documented in the Safety Case

6.4.1 Identification and Description of Major Hazards

6.4.2 Risk Ranking of Hazards

6.4.3 Major Hazards Quantitative Risk Analysis

6.4.4 Quantitative risk expressions

6.4.4.1 Probable loss of life (PLL)

6.4.4.2 Individual risk (IR)

6.4.4.3 Temporary Refuge Impairment (TRI) frequency

6.4.5 Method used for QRA by AHL

6.4.6 Risk Tolerability criteria

6.4.7 ALARP

6.4.8 Temporary Refuge Impairment

6.4.9 Demonstrating ALARP

6.4.10 Risk Management

6.5 Detailed QRA Methodology

6.6 Best estimate and uncertainty analysis
6.6.1 Initiating Event
   6.6.1.1 Best estimate analysis
   6.6.1.2 Uncertainty analysis
6.6.2 Ignition Probability and Delayed Ignition
   6.6.2.1 Best estimate analysis
   6.6.2.2 Uncertainty analysis
6.6.3 Delayed Ignition Probabilities
   6.6.3.1 Best estimate analysis
   6.6.3.2 Uncertainty analysis
6.6.4 Fire and Gas Detection Failure Probabilities
   6.6.4.1 Best estimate analysis
   6.6.4.2 Uncertainty analysis
6.6.5 Isolation and Blowdown Failure Probabilities
   6.6.5.1 Best estimate analysis
   6.6.5.2 Uncertainty analysis
6.6.6 Deluge Failure Probability
   6.6.6.1 Best estimate analysis
   6.6.6.2 Uncertainty analysis
6.6.7 Escalation Probabilities
   6.6.7.1 Best estimate analysis
   6.6.7.2 Uncertainty analysis
6.6.8 Immediate Fatalities
   6.6.8.1 Best estimate analysis
   6.6.8.2 Uncertainty analysis
6.6.9 EER Fatalities
   6.6.9.1 Best estimate analysis
   6.6.9.2 Uncertainty analysis

Chapter 7  Improvements to AHL Risk Analysis Process

7.1 Introduction

7.2 The Problems that Require Attention
7.3 The Proposal for **Modifying** the Event Tree Analysis 268
7.4 Truncating the Normal Distribution 276
7.5 Methodology of the Software Used for this Case Study 277
7.6 How Many Iterations? 279
7.7 The Results of the Simulation 282
  7.7.1 The Input Distributions 285
  7.7.2 The Output Distribution 287
7.8 Advantages of this Improved Technique 293

Chapter 8 Conclusions
8.1 Introduction 296
8.2 Conclusions from the Literature Survey 297
8.3 Conclusions based from Risk Management Questionnaire 297
8.4 Conclusion based from the Case Study 300

Chapter 9 Recommendations for Future Work
9.1 Introduction 303
9.2 Future Research 303

References 307

Glossary 326

Appendices

Appendix A Risk Management Questionnaire A-1
Appendix B Introductory letter to the Construction and Oil companies B-1
Appendix C The means, standard deviations and sample sizes of all the divisions for questions 4 to 49 of the Questionnaire C-1
Appendix D Full analysis of the characteristics for each of the types of risks in questions 50-57 D-1

xi
Appendix E  Mean values and sample size tables for the two industries in questions 50-57  E-1
Appendix F  Overall mean values and samples size table for questions 50-57  F-1
Appendix G  ALARP methodology  G-1
Appendix H  Calculation for overall uncertainty for leak frequencies  H-1
Appendix I  Propagation of uncertainty  I-1
Appendix J  Ignition probabilities  J-1
Appendix K  Double log-graph to find best estimate ignition probability  K-1
Appendix L  Probability of spurious values when using normal distributions  L-1
Appendix M  The mean and skewness values of the 10 runs for the six iteration amounts  M-1
Appendix N  Graphical representations of the input normal distributions  N-1
Appendix O  Linked data to Figure 7.1  O-1
Appendix P  Published Material  P-1