# RISK MANAGEMENT

## CHEMICAL ENGINEERING THROUGH THE EYES OF A CONSULTANT

A Work Experience Report

by

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Chemical Engineering Department
Senior
First Co-op Work Term
Det Norske Veritas – DNV
Fall 2013

presented to

Dr. Victor M. Ugaz
Texas A&M University

December 30, 2013

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# Abstract

In Fall 2013, I interned with DNV in the Oil & Gas Division as an associate consultant for the Risk Management Solutions Department. I was placed in the Safety Risk Analysis group, but I also worked with the Safety Systems Risk and Environment & Navigational Risk groups. My work experience was unique because it is not very common for interns in DNV to be responsible for a specific project. Instead, I contributed to several projects among the three aforementioned groups. The projects I supported covered a variety a topics, including Quantitative Risk Assessments (QRAs), proposal writing, Safety Cases, Hazard and Operability Study (HAZOP), Visual Basic Applications (VBA) coding, and safety management. My broad involvement across the department gave me the opportunity to learn about the different topics related to risk management consulting and safety, as well as the demands of the Oil & Gas Industry. In addition to technical knowledge, I gained experience in many areas of communication, such as technical writing, scribing, presenting for different audiences, and professional interactions. Most importantly, I realized that safety is my area of interest.

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## Introduction

In the fall 2013, I completed my first Co-op term with Det Norske Veritas, better known as DNV. During my term, I worked as an associate consultant for the Risk Management Solutions (RMS) Department within the Oil & Gas Division of North America located in Katy, TX. The RMS Department is divided into four sections: Safety Risk Analysis, Safety Systems Risk, Asset Risk, and Environment & Navigation Risk. Although I was originally placed under the Safety Risk Analysis group, I worked interchangeably among the different groups, with the exception of the Asset Risk group. My internship with DNV was unique because I was not responsible for a major project. Instead, I participated in a variety of projects among the three sections mentioned above.

I spent my first few months working interchangeably between the Safety Risk Analysis and Safety Systems Risk groups. As the names imply, both groups identify, estimate, and manage the inherent risks involved with processes related to the oil and gas industry as well as chemical facilities. This is achieved by DNV's proprietary software packages called Phast (Process Hazard Analysis Software Tool) and Phast Risk. Phast is a comprehensive consequence modeling software tool which is applicable to all stages of design and operation across a wide range of process industries. Phast Risk analyzes complex consequences from release scenarios, taking into account the failure frequency, local population and weather conditions to quantify the risks associated with the release of hazardous materials. Safety Risk Analysis' emphasis is on quantifying the frequency and consequences of risk, while Safety System Risk focuses more on identifying potential risks and consequences qualitatively. Once risks, causes, and consequences are known, both groups help the client control the process through recommendations such as implementing barriers that may prevent hazardous releases from happening or mitigate consequences in case of realization of a hazard. Similarly, the Environment & Navigation Risk section focuses on the risk involved in the transportation of vessels, including risk to the people, the vessel, and the environment. An example of such risk is a collision that may result in loss of containment and / or ignition.

The projects I supported covered a variety of topics, such as Quantitative Risk Assessments (QRAs), risk modeling, proposal writing, safety cases (including BowTies preparation and personnel training material), Hazard and Operability Study (HAZOP), and safety management systems. Since I was involved in many different projects I did not get the opportunity to gain a deep understanding of a particular subject, however, it gave me the opportunity to explore the different paths an engineer can take as a risk management consultant.

## ***DNV in Brief***

Det Norske Veritas (DNV), which translates to "The Norwegian Truth", is a knowledge-based company dedicated to *"safeguard life, property and the environment*[3]*."* Since 1867, DNV has been an independent and international organization with approximately 300 offices in more than 100 counties, with headquarters in Oslo, Norway. DNV started as a ship classification society that inspected and evaluated the condition of commercial vessels. Since its inception, DNV has expanded its services with one target in mind, to "*identify, assess, and advise on how to manage risk*[2]*"* with the goal of teaching its clients how to safely and responsibly improve business performance.

Although DNV's services apply to many different industries, its main business targets are maritime, oil & gas, energy & power, and business assurance. Therefore, DNV has divided its service lines into three divisions:

- Maritime and Oil & Gas Division, which provides classification, verification, risk management and technical advisory services
- Energy & Sustainability Division, which provides consulting, testing, and certification services to sectors such as renewable energy, power generation, and energy efficiency
- Business Assurance Division, which provides certification, assessment and training services related to customers' products, processes, and [4].

In addition to these services, DNV produces software for modeling and estimating risk, as well as assessing asset performance. DNV also continually allocates funds to research dedicated to improving and developing new services, rules, and industry standards.

Through its history, DNV has acquired several smaller companies, such as KEMA. Recently, DNV merged with Germanischer Lloyd (GL) to become DNV GL. This newly integrated company has 16,000 employees working to achieve *"Global impact for a safe and sustainable future[4]."* The merger with GL was announced in 2012 but did not take place until September, 2013. Therefore, I was able to witness some of the changes these two organizations went through, such as modifications to the brand, management, and introduction of new businesses and locations.

## Objectives

My primary goal starting this Co-op was to gain technical knowledge and to further develop the creative mentality that an engineering career demands. I anticipated opportunities to study, analyze, and optimize processes related to chemical engineering. I imagined projects that required application of theories and techniques that I was taught in the classroom. In addition to this technical experience, I wanted exposure to a professional environment to improve my communication skills, such as public speaking, making presentations, and technical writing. By the completion of my work term, I wanted to have a better understanding of how my school course work relates to the industry, more specifically to the fields of engineering consulting and risk management.

## Activities and Acquired Skills

This section discusses the projects I assisted, along with my contribution and the knowledge and skills I obtained from each project. My involvement with most projects took place at the middle stage where major tasks had already been delegated. Therefore, my participation was often very brief (1-3 weeks long) and only involved one particular task. Due to confidentiality issues, the name of the company and projects cannot be disclosed. Henceforth, I will refer to the company as “the client.”

### ***Guidelines for Quantitative Risk Assessment (QRA) of Pipelines***

This “in house” project was delegated to me my first week at DNV and continued for approximately two weeks. The project consisted of examining two DNV reports from previously performed Quantitative Risk Assessments (QRAs) of pipelines, and extracting general procedures into one document. The purpose of this document is to serve as general guidelines for co-workers to follow in future risk assessments of hazardous gas or liquid pipelines. This was a very interesting task for me because this was my first time learning about risk and QRAs. Nonetheless, I managed to teach myself enough material, from training presentations, to comprehend the objectives and scope of work of the project reports I was analyzing.

After closely studying and comparing the reports, I identified 5 major steps: 1) Data gathering, 2) Predicting the frequency of the failures considered, 3) Estimating the consequences of the failure scenarios, 4) Calculating risks and assessing the risk against risk acceptance criteria, and 5) Identifying site-specific risk reduction measures. I then explained in depth the additional steps and information, such as population, weather conditions, ignition sources and physical properties of the substance released, required within each of these 5 major steps.

From this project I got acquainted with risk terminology, methods of risk assessments, and risk presentation techniques. Primarily, I learned that risk is defined as a measure of the impact of undesired hazardous events and how likely they are to occur. In a more simplistic definition,

**RISK = Likelihood X Consequence**

Risk estimation often depends on many different factors such as weather conditions, chemical and physical properties of materials / substances, etc. Risk can be expressed as individual risk or societal risk. Individual risk (IR) is the risk experienced at a single point in a given time period (usually a year) and is therefore independent of the actual number of people present in the area. Individual risk is often shown as risk contours (see Figure 1) which are lines connecting locations with the same level of risk. Societal risk (SR) is defined as the probability that a group of more than N persons would be killed due to an accident from the hazardous activity, and it is often presented using FN curves (see Figure 2). An FN curve is a graphical measure of societal risk that shows the relationship between frequency and size of the accident. This allows a measure not only for the average number of fatalities from all sizes of accidents, but also the risks of catastrophic accidents that may impact many people at once.

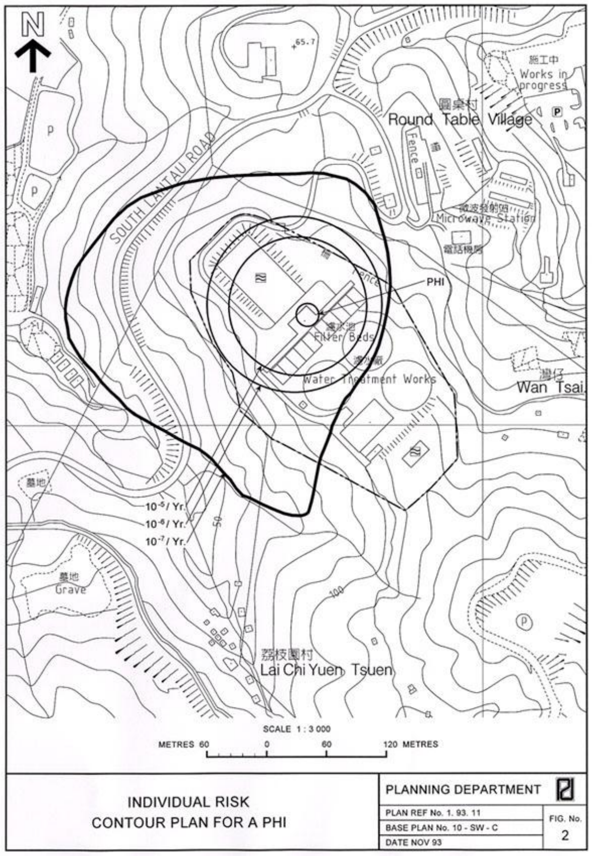


**Figure 1 Example of IR Contour[8]**

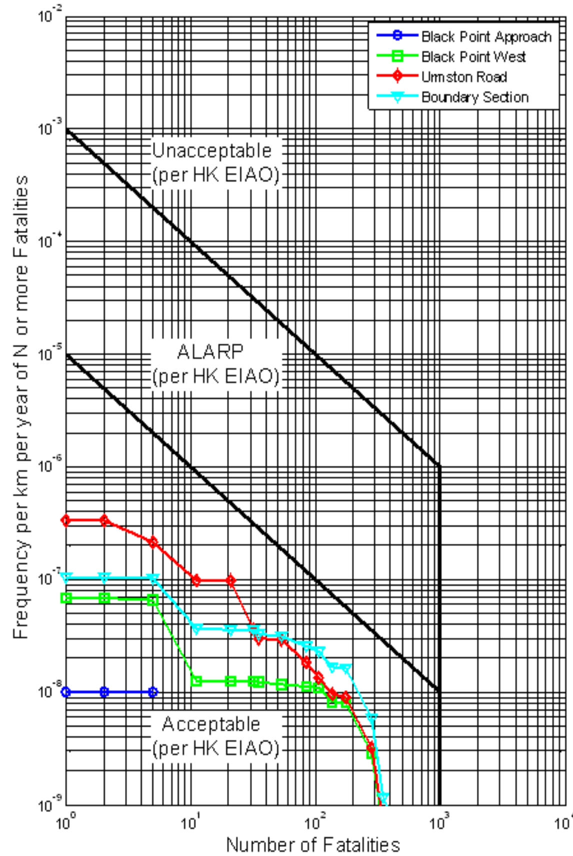


**Figure 2 Example of FN Curve[1]**

Once risk is identified, estimated and assessed, it needs to be managed. Risk Matrices and risk acceptance criteria are often utilized to categorize risk to help determine if actions are needed. As seen in the risk matrix in Figure 3, risk may be classified based on its consequence and likelihood. Low likelihood and low consequence risks (green region) are considered acceptable and no further action is needed. Medium likelihood and medium consequence risks (yellow region) are said to be in the ALARP (As Low as Reasonably Practicable) Region. These types of risk are not considered a big threat, but it is recognized that additional measures should be taken to further minimize the risk if the cost is reasonable. Those risks that present a real danger and require immediate action are those with high likelihood and high consequence (red region).


**Figure 3 Risk Matrix**[7]

***Quantitative Risk Assessment (QRA) for a Liquefied Natural Gas (LNG) Plant***

For this project, an American energy corporation requested DNV to provide safety risk advisory services for an LNG terminal project. The scope of work included a Consequence Analysis (CA) and a Quantitative Risk Assessment (QRA) for the terminal. The main objective was to identify credible accidental scenarios and assess the severity and likelihood of those consequences resulting in damage to personnel and assets on the facility. Credible worst case scenarios were first identified based upon review of the process design documents. Secondly, a complete assessment was performed for each of these scenarios to address potential impact to people and assets.

I participated in the Consequence Analysis, which focused on consequences from hazardous releases, such as gas dispersion, fire radiation, and explosion overpressure, from the worst credible scenarios identified. In this project, I became the "Overpressure Guru." Potential LNG spills and collection in sumps were modeled using PhastRisk. The model analyzed the likelihood and consequence of having an LNG release into an area of congestion causing an explosion. I was in charge of extracting the list of all possible combinations of frequency and overpressure levels at different locations as the result of such explosion.

Due to a large amount of raw results data, the information was extracted in pieces (Train 1 data and Train 2 data). Since the two trains are identical, the combined data contained a lot of repetition and needed to be processed. This process consisted of deleting the duplicates, and finding the frequency of certain overpressure levels specified by the client. Although it is a very simple process, it can be very tedious, repetitive, and time consuming. Therefore, once I understood the results and the objectives of my task, I decided to write a macro to speed up the process. This was a very interesting assignment because I had never written a macro code. But I was very motivated and determined to find a better approach to this problem.

Towards the end of the project, the team realized that an input value was wrong, which meant that all the data needed to be extracted and processed again. There was some concern that there would not be enough time to finish by the deadline. However, my macro introduced a more efficient method. The new data was processed in less than an hour, giving the team more time to focus on other areas. The main takeaway from this project is how important it is for engineers to always ask "How can I make this better?" Part of this mentality involves thinking outside the box and trying things outside our areas of expertise. In my case, I took the initiative of exploring Visual Basic for Applications (VBA) in Excel to make a process more efficient. This motivated me to learn more about coding.

### ***HSE (Health, Safety and Environmental) Management Systems Assessment***

The client in this project is an Offshore Service Vessels (OSVs) provider for energy companies that operate in remote areas of the world. In order to meet new demands, the client is in the process of incorporating Remotely Operated Vehicle (ROV) services into their current service line. However, these two service lines are very different and although their current HSE Management System is appropriate for OSV operations, it may not be sufficient for the new subsea services. DNV was asked to evaluate the company to determine how prepared the organization is for ROV operations with their current management system. The project involved an assessment of the company's HSE Management System to determine what changes may be needed to meet the needs of the new business.

The assessment consisted of two separate studies. One part involved a high level (element level) analysis of the client's Safe Operations Systems (SOS) and Safety Management Systems (SMS) manuals, and comparing them against the Gulf of Mexico Safety and Environmental Management Systems (SEMS) requirements. "The SEMS is a nontraditional, performance-focused tool for integrating and managing offshore operations[6]." The standards set in SEMS intend to minimize risk to ensure safe operations. The goal of the first study was to identify gaps in the existing safety manuals based on SEMS requirements. The second part aimed to determine the maturity level of the HSE Management System based on the International Safety Rating System (ISRS8). The ISRS8 is the eighth edition of DNV's "system to assess, improve and demonstrate the health of an organization's business performance[5]." The maturity level of an organization can be determined by evaluating the structure and implementation of the HSE Management system through discussions with employees across the departments.

My participation in this particular project was more in depth than in any of the other projects. I was involved from beginning to end. My first role was to scribe for 27 interviews that DNV held with the study participants. I was also responsible for categorizing the comments collected from the interviews by the 15 elements states in the ISRS8 (see Figure 4). I also performed a high level examination of the SMS Manual to determine if the ISRS8 15 elements were covered. Finally, I collaborated with the final report.


**Figure 4 ISRS8 15 Elements**

This project not only gave me the opportunity to learn about safety management systems, but also to directly interact with the client. I was in charge of setting up some of the interviews, which I accomplished through email and phone calls. This allowed to enhance my communication and organizational skills, as well as to learn how to communicate professionally. This was my favorite project because I had the chance to participate in all the steps involved (from data gathering and interactions with the client to report writing), which allowed for me to fully understand the objectives and the scope of work of the project.

## ***Other Minor Projects***

In addition to these major projects, I was also involved in other minor projects that reinforced my understanding of risk management in the Oil & Gas Industry. In a Safety Case project, I formatted Power Point presentations that were used to train personnel at the rig on how to manage risk. From this, I learned about the different jobs and roles involved in drilling. I also helped with the preparation of a proposal for a TERMPOL (Technical Review Process of Marine Terminal Systems and Transshipment Sites) Study. I did not necessarily learn about how to perform the studies in the TERMPOL Code, but I gained a valuable experience on the bidding process. Finally, I created a presentation for a HAZOP (Hazard and Operability) Study orientation. From this experience, I learned that a HAZOP Study is a systematic approach to manage process safety incidents. I also discovered several ways to communicate a process to different audiences, such as text, diagrams, videos, etc.

## Conclusions and Reflections

My Co-op at DNV gave me the opportunity to gain a broad knowledge about the services and techniques related to risk management, as well as a better understanding of the demands of the Oil & Gas industry. The broad involvement I had across the department provided me with a comprehensive view of the opportunities I could have as a risk management consultant. I learned how important it is to have a third party, like DNV, assess a company's HSE (Health, Safety & Environmental) Management System, engineering processes, and operations to help the organization identify and manage risks. Most importantly, I obtained the exposure I needed to improve in some of the areas of communication, such as proposal / report writing, scribing, and preparing presentations for different audiences. I have learned that consulting is a fascinating career that would allow me to accomplish one of my goals when I decided to study engineering - positively impacting the lives of people. I may not have entirely fulfilled my goal of gaining technical experience, but I did acquire the experience and knowledge I needed to endorse my interest in safety.

My time at DNV also made me realized the importance of pursuing a higher degree and furthering my education. As an intellectual based company, DNV highly values the knowledge and competency of its workers. This has reinforced my decision of obtaining a Safety Engineering Certificate as part of my undergraduate curriculum. Previous to my Co-op, I had the idea that a Masters and a PhD degree were only useful for a position in Research and Development but not for other fields in the industry. My colleagues have inspired me to pursue a Master's degree. However, I would first like to spend at least three years in the field to develop an area of interest.

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