UNIVERSIDADE ESTADUAL DE CAMPINAS
FACULDADE DE ENGENHARIA MECÂNICA
E INSTITUTO DE GEOCIÊNCIAS

EVA MARGARETH CODDIA MICHEL

MINING, STRUCTURING AND DISSEMINATION OF SPECIALIZED PETROLEUM ENGINEERING KNOWLEDGE

MINERAÇÃO, ESTRUTURAÇÃO E DISSEMINAÇÃO DE CONHECIMENTO ESPECIALIZADO EM ENGENHARIA DE PETRÓLEO

CAMPINAS
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Dissertation presented to the Mechanical Engineering Faculty and Geosciences Institute of the University of Campinas in partial fulfillment of the requirements for the degree of Master in Petroleum Sciences and Engineering in the area of Exploitation.

Dissertação apresentada à Faculdade de Engenharia Mecânica e Instituto de Geociências da Universidade Estadual de Campinas como parte dos requisitos exigidos para a obtenção do título de Mestra em Ciências e Engenharia de Petróleo na área de Explotação.

Orientador: Prof. Dr. Celso Kazuyuki Morooka

Coorientador: Prof. Dr. Kazuo Miura

Este exemplar corresponde à versão final da Dissertação defendida pelo aluno Eva Margareth Coddia Michel e orientada pelo Prof. Dr. Celso Kazuyuki Morooka.

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UNIVERSIDADE ESTADUAL DE CAMPINAS
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DISSERTAÇÃO DE MESTRADO ACADÊMICO

MINING, STRUCTURING AND DISSEMINATION OF SPECIALIZED PETROLEUM ENGINEERING KNOWLEDGE

Autor: Eva Margareth Coddia Michel

Orientador: Prof. Dr. Celso Kazuyuki Morooka
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RESUMO

A aquisição e transmissão de conhecimento são tarefas essenciais que todos os indivíduos e empresas devem enfrentar para subsistir e progredir. Na indústria do petróleo grandes quantidades de textos são estruturados diariamente para facilitar a disseminação de conhecimento, mas o ser humano não tem a habilidade de ler, compreender e lembrar tal quantidade de informação sem ajuda de sistemas computadorizados.

Com o propósito de promover a disseminação de conhecimento sobre a engenharia petrolífera a dissertação propõe uma metodologia que permite a aquisição e a disseminação do conhecimento. A metodologia permite extrair os conhecimentos contidos em documentos textuais e mostrá-los graficamente usando mineração de textos e técnicas de visualização.

Tal metodologia foi aplicada em duas bases de dados que são Alertas de Segurança da BSEE e teses de doutorado e dissertações de mestrado da UNICAMP as considerando repletas de conhecimento para a indústria de petróleo.

A metodologia foi aplicada duas vezes na base de dados da BSEE. A primeira vez para conhecer o conteúdo geral e a segunda para especializar o conhecimento sobre a construção de poços. Os resultados obtidos são "conceitos relevantes" referentes à construção de poços sobre os quais foram construídas três estruturas de conhecimento. Estas estruturas evidenciam as relações existentes e a relevância desses conceitos. Os modelos de conhecimento estruturado obtidos podem ser utilizados para disseminar conhecimento, classificar lições aprendidas, treinar pessoal, visualizar e navegar em conteúdo.

O resultado principal desta aplicação é um Grafo de Conhecimento Multicamada que permite a busca por conteúdo e a eficiente recuperação de documentos.

A qualidade dos resultados oriundos desta metodologia foram confirmados através de dois testes. O primeiro teste consistiu em buscar dentro da base de dados da UNICAMP, documentos relevantes para estudantes do programa de pós graduação em ciências e engenharia de petróleo (CEP) que estavam realizando trabalhos em diferentes linhas de pesquisa. O segundo teste incidiu em encontrar Alertas de Segurança utilizando palavras chaves idênticas por diferentes motores de busca (motor de busca da BSEE, Google e o método proposto).

Os resultados obtidos em ambos os testes mostram a efetividade da metodologia proposta em processar bases de dados locais e especializadas.

Palavras Chave: Aquisição e disseminação de conhecimento, Engenharia de petróleo, Busca por conteúdo, Relevância, Conhecimento estruturado.

ABSTRACT

Acquisition and transmission of knowledge are essential tasks that all individual and enterprises face to subsist and progress. In the petroleum industry large amounts of texts are daily structured to facilitate the dissemination of knowledge but the human being does not have the ability to read, comprehend and remember such amount of information without the help of computerized systems.

With the purpose of promoting the dissemination of knowledge about the petroleum engineering the dissertation proposes a methodology that allows acquisition and dissemination of knowledge. The methodology enables to extract the knowledge contained in textual documents and illustrates it in a graphical format, using text mining and visualization techniques.

Such methodology has been applied in two databases, BSEE's Safety Alerts and doctoral thesis and master dissertations from CEP-UNICAMP, considering them meaningful sources of knowledge for petroleum industry.

On BSEE's database, the methodology has been applied twice. The first time to notice the general content and the second time to specialize the knowledge on well construction. The results obtained are "relevant concepts" about well construction, with which were built three structures of knowledge. Those structures display the relevance and relationship between concepts and can be useful to disseminate knowledge, classify learned lessons, train personnel, visualize and navigate on content.

The main result of application is a "Multilayer Knowledge Graph" that allows the research for contents and efficient documents recovery.

The quality of results provided by the methodology were confirmed by two tests. The first test consisted to find relevant documents to graduate students of the CEP (Graduate program in petroleum science and engineering) from UNICAMP's database, who were carrying out works in different lines of research. The second test consisted to find Safety Alerts by using identical keywords but different search engines (BSEE's search engine, Google and the proposed method). Results obtained from both tests demonstrated the effectiveness of the proposed methodology in processing local and specialized databases.

Key Words: Acquisition and dissemination of knowledge, Petroleum engineering, Search for content, Relevance, Structured knowledge.

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LIST OF ABREVIATIONS AND ACRONYMS

BSEE	Bureau of Safety and Environmental Enforcement
CEP	Graduate Program of Petroleum Science and Engineering
D	Dictionary of words
Doc.	Document
FEM	Faculty of Mechanical Engineering
G	Grammar
G(K)	Specialist Grammar
IDF	Inverse Document Frequency
IG	Geoscience Institute
MMS	Mineral Management Service
O&G	Oil and Gas
OCS	Outer Continental Shelf
PhDic	Phrase Dictionary Tool
S	Set of texts
SA	Safety Alerts
TF-IDF	Term Frequency Inverse Document Frequency
U.S.	United States
UNICAMP	University of Campinas

LIST OF SIMBOLS

E%	Error percentage
Freq	Frequency
H	Shannon entropy
K	Constant of Shannon Entropy
N	Number of documents in the database
Sk%	Percentage increase of knowledge sources
df	Document frequency
f	Frequency
p	Probability
w	Weight
i	Term
j	Document
max	Maximum
ℓ	Euler's Number ℓ=2.718281828

TABLE OF CONTENTS

1. INTRODUCTION

Share knowledge and contents are not just important but primordial to the companies keeps a good development.

The knowledge can be understood as comprehend and assimilate information. The acquired acquaintance by two different persons will never be the same even if both people had access to the same sources of information.

Now transmit knowledge person to person is a very difficult task to perform. Many information could be lost or distorted (see Figure 1.1) when a person with experience tries to transmit the knowledge (represented by arrows in Figure 1.1) to people with few or without experience. It happens because different people have different awareness.

The companies must have the concern that people come and go, but the knowledge can be kept if they had good ways to structure the knowledge.

Nowadays find ways to spread out knowledge effectively is the big challenge to the companies.

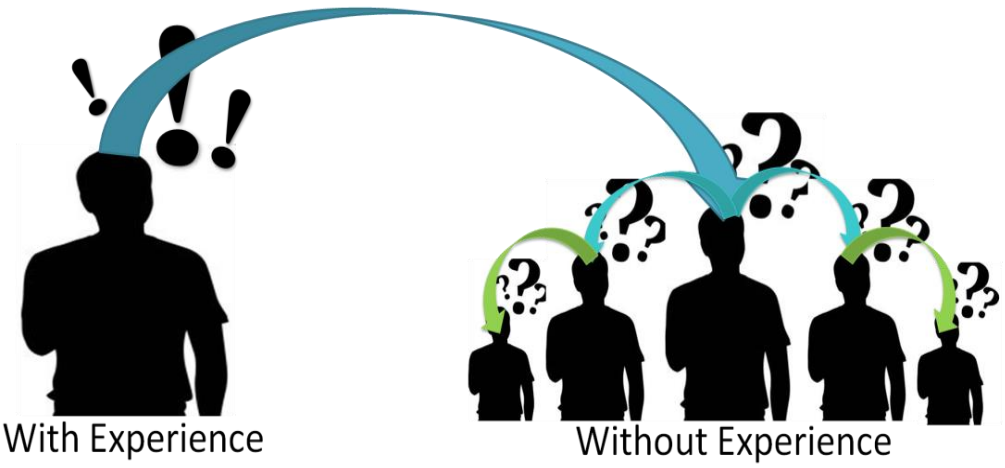


Figure 1.1 Representation of knowledge transmission, from an experienced person to inexperienced people. Knowledge is represented by arrows, and the different colors represent de distortion of knowledge.

In petroleum industry textual documents are the most common structure used for knowledge transmission. Large amounts of documents containing valuable information are routinely generated and shared. Such as: Safety Alerts, doctoral thesis, master dissertations, papers, journal articles, technical reports etc.

With technological improvements a new problem arose. The quantity of important information increases considerably, reducing the spread of knowledge.

There are two main factors affecting knowledge dissemination:

1) The limited capability of human being

Human beings are not able to read, understand and remember large amounts of information if it is not classified in small groups. This statement is based on the following information:

Psychologists perceived that the human being can perform the function of a communication channel, and some experiments were carried out to measure its performance. Miller (1967) describes in detail various experiments, he observed that the quantity of random digits a person can correctly remember and the quantity of phrases that can be inserted in a sentence and still be read through without confusion is “seven plus or minus two”. He named it “magic number”.

Moreover, Nicolis and Tsuda (1985) confirm that the “human channel” possess the ability of compressing almost an unlimited number of bits per symbol per second or per category.

2) Impossibility to search for content

Search for content in big databases is a difficult and time-consuming task if performed with conventional search methods because they were developed on the basis of traditional bibliographic categorization that uses the information of title, author, date, or keywords (designated by the author) to organize items concerning to the same subject in the same area so they can be easily and quickly found.

The technological evolution experienced the last few years caused the establishment of digital libraries, the augmentation of production of documents and the enhancement of their diffusion. In consequence the quantity of available information increased exponentially and conventional search methods used for retrieval information were no longer effective. Therefore, search engines are developed constantly.

Search engines are software systems designed to search for information on the World Wide Web or particular web sites. Google is representative of the variety of easy-to-use search engines. These type of software aim to help find as easily as possible a necessary information. Two examples of search engines of particular websites will be presented in Section 2.1.

Several researchers have tried to build the "perfect" search engine, focusing on the improvement of searching by keywords, permitting users to specify the required information through meta-data, natural language, and context (Teevan et al. 2004).

Teevan et al. (2004) commented about a very common difficulty, that people never find the things when they need them. It often happens when people remember about something they read before and try to find the source of that information. In most cases this is an exhausting task and takes time. This difficulty that almost everybody has to face at least once, could be explained by the fact that keywords of documents are specified by the authors according what they think is relevant. But is important to note those keywords do not always display relevant information for the user. With the purpose to provide access to relevant content, the dissertation has the following objective.

1.1. Objective

The objective of the present dissertation is:

"Enable search for relevant content in structured knowledge of petroleum engineering".

Concepts of "relevance" and "structured knowledge" will be clarified in Chapter 2.

To achieve the objective, this work proposes a methodology that allows extracting knowledge from textual databases and illustrates it in a graphical format to improve its dissemination.

The proposed methodology will be applied in two databases with different characteristics of language and content, proving that it can be applied in any textual database if it is local and specialized.

Several things were studied and tasks were performed to reach the objective of this work. All this information was organized and will be presented in the document as outlined in the following section.

1.2. Dissertation overview

This Dissertation is divided in 6 chapters:

Chapter 1 contains a brief description of main problems affecting knowledge dissemination in petroleum industry, outlines the objective of this work and describes how this document is organized.

Chapter 2 presents basic concepts for the better understanding of the work and describes the context in which the methodology will be applied.

Chapter 3 describes the proposed methodology to acquire and structure knowledge

Chapter 4 presents the results obtained from the application of the methodology in BSEE's and CEP-UNICAMP's database.

Chapter 5 presents the conclusions of this work.

2. BASIC CONCEPTS AND CONTEXT EXPLANATION

The purpose of this chapter is explain the context and clarify basic concepts essential for the comprehension of this work.

“Structured knowledge” and “relevance” are two main concepts that must be explained to understand the objective presented in Chapter 1. Those concepts and their application examples are presented in Section 2.1 and Section 2.2 respectively.

The Section 2.3 describes the text mining process that allows to access the contents of large databases and provides the information of their frequency of occurrence.

The last section of this chapter, Section 2.4 presents different ways to visualize data, information and knowledge.

2.1. Structured Knowledge – Explicit and Tacit Knowledge.

In this Section the terms Structured Knowledge and Explicit and Tacit Knowledge will be defined.

Prior to define Structured Knowledge, the difference between data, information and knowledge should be clarified. The Figure 2.1 will be helpful to enhance the comprehension of these difference.

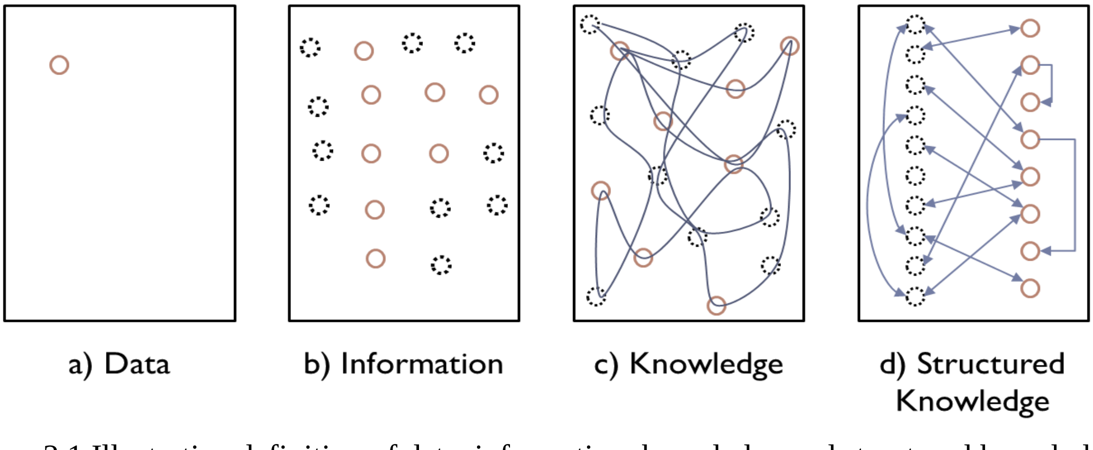


Figure 2.1 Illustrative definition of data, information, knowledge and structured knowledge.

The Figure 2.1 is a representation of the following definitions:

- **Data** are numbers or individual entities without context or significance. (Chen et al. 2009).
- **Information** is data that has been processed to be useful providing answers to questions such as “who”, “what”, “where” or “when” (Ackoff, 1989).

– **Knowledge** is the application of data and information and the relationship of information, providing answers to questions of "How" (Ackoff, 1989) and "why".
– **Structured Knowledge** could be understood as any kind of represented structure of information on which a system is capable to perform reasoning. (Adapted from Skalle et al. 2014).

The terms, explicit knowledge and tacit knowledge, will be useful to understand the results obtained by the methodology and comprehend its importance.

Dienes and Perner (1999), Wyatt (2001) and Smith (2001) are some examples of works that present definitions of explicit and tacit knowledge in the literature. The Figure 2.2 represents the difference between those terms.

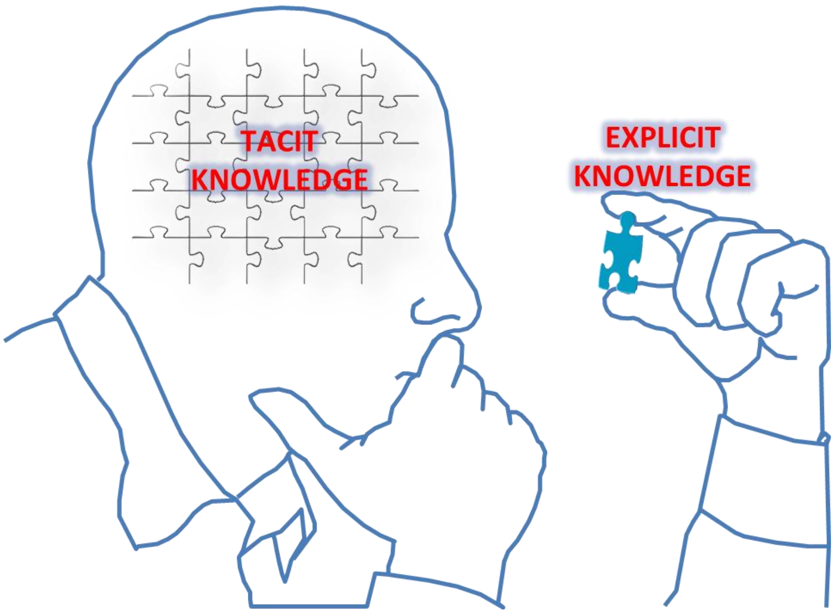


Figure 2.2 Explicit and Tacit knowledge Illustration.

In Figure 2.2 is possible to observe that explicit knowledge is understand as visible information.

Tacit knowledge is not visible but it is obtained from the comprehension of visible information.

Therefore, visible information and explicit knowledge could represent the same thing but from different perspectives.

The information becomes knowledge after its applicability is recognized. The methodology proposed (Chapter 3) aims to show the relevant information for different user's needs.

Below here some examples of structured knowledge used in petroleum industry and its explicit and tacit knowledge are described.

- **Structured knowledge of petroleum engineering**

Textual documents are the most common kind of structured knowledge used in Oil and Gas (O&G) industry, some examples of this are: Safety Alerts, daily reports of occurrences, non-compliance reports, thesis, dissertations, papers, journals, books, among others.

The conventional structured knowledge, textual documents based, represents a big disadvantage at the moment to search for relevant content as mentioned in Chapter 1.

Another kind of structured knowledge is the one that uses data visualization techniques, such as charts that relate two or more variables (e.g. year vs. frequency of accidents). Oliveira (2004) and Izon et al. (2007) are some examples of works that widely used this kind of structures.

Moreover, in Miura (1992), Skalle et al. (2014), Zhou et al. (2007) Mohammadfam et al. (2013) and Hollnagel et al. (2008) were presented another type of structured knowledge that are graphical representation of information and their relationships, better known as knowledge graphs.

The structured knowledge used as input of the methodology are textual documents, BSEE's Safety Alerts and CEP-UNICAMP's doctoral thesis and master dissertations, denominated:

a) BSEE's Database

The first database used in this work contains Safety Alerts of the Bureau of Safety and Environmental Enforcement (BSEE). Website: http://www.bsee.gov/.

BSEE previously known as MMS (Mineral Management Service) is a regulatory program that develops standards and regulations to enhance operational safety and environmental protection, for the exploration and development of offshore O&G on the U.S. OCS (United States Outer Continental Shelf). OCS Regions where BSEE has offices are shown in Figure 2.3.

Figure 2.3 BSEE Regional offices in OCS.
Source: BSEE (2015).

BSEE is supported by three regional offices in Alaska, Pacific and Gulf of Mexico. Those offices are responsible to ensure that all safety requirements are met and that inspections of drilling rigs and production platforms are conducted.

Reports of accidents occurred over the year are issued by BSEE and presented on their website for public consultation. According to Oliveira (2004) when a trend of accidents with a common causal factor is identified through the year, a Safety Alert is generated and also published in their website as displayed in Table 2.1.

Safety Alerts are "Tools to inform the offshore O&G industry of the circumstances surrounding an incident or near miss and recommendations that should help to prevent the recurrence of such incident on the OCS" (BSEE 2015).

BSEE`s website provides the following information about Safety Alerts: A list of Safety Alerts classified by safety alert number, title and date (see Table 2.1); Statistics of incidents/spills by year, (see Figure 2.4); Search engine (seeker) that allows to search on the website information by using keywords. All this visible information has been considered as explicit knowledge by the author.

On the other hand, this website doesn't provide a direct access to the content of Safety Alerts nor common or “relevant” information. Therefore, were considered tacit knowledge.

Table 2.1 List of Safety Alerts available in the BSEE website.

Safety Alert Number	**Title**	**Date Issued**
No.317	Catastrophic Incident Avoided	06/12/2015
No. 316	Aviation Near Miss	06/12/2015
No. 315	Dynamic Positioning System Failures on Offshore Supply Vessels Engaged in Oil and Gas Operations in the U.S. Outer Continental Shelf	02/24/2015
No. 314	Operator Electrocuted Trying to charge a Battery	09/23/2014

Source: BSEE SA. 2015.

OCS Incidents/Spills by Category: CY 2008 - 2015 ytd

TYPE (Click for more info)	2008		2009		2010		2011		2012		2013		2014		2015 ytd	
	GOM	PAC	GOM	PAC	GOM	PAC	GOM	PAC	GOM	PAC	GOM	PAC	GOM	PAC	GOM	PAC
FATALITIES	11	0	4	0	12	0	3	0	4	0	3	0	1	0	0	0
INJURIES *** #	318	14	285	16	273	12	213	18	253	34	246	22	244	33	110	2
LOSS OF WELL CONTROL ***	8	0	6	0	4	0	3	0	4	0	8	0	7	0	1	0
FIRES/EXPLOSIONS	139	12	133	12	126	4	103	2	134	6	103	8	105	16	51	3
COLLISIONS ***	22	0	29	0	8	0	14	0	9	1	23	0	12	0	4	0
SPILLS ≥ 50 bbls	33	0	11	0	5	0	3	0	8	0	^	^	^	^	^	^
OTHER ***	278	36	308	28	155	17	186	15	236	41	278	43	297	55	170	13
INCIDENT TOTAL FOR THE YEAR	809	62	776	56	583	33	525	35	648	82	661	73	666	104	336	18
COMBINED TOTAL FOR THE YEAR	871		832		616		560		730		734		770		354	

SOURCE: BSEE Database as of 3-Aug-2015 | Incidents Archive

^ Spill Data after CY 2012 is available here

NOTE: Incidents may be counted in more than one category. For example, a fire resulting in an injury would be counted in both the fire and injury category.

Figure 2.4 Table of incidents/spill categorized by year, available in the BSEE website.
Source: BSEE Incidents, 2015.

The methodology here proposed aims to evidence the tacit knowledge. The importance and the great advantage that it could represent for the petroleum industry will be shown in Chapter 4.

BSEE's database used for this study consists of 352 Safety Alerts, published since September 1972 until June 12th, 2015, that contains information of offshore O&G industry.

As a way to show the potential of the proposed methodology, knowledge referent to well construction activities was extracted from this database. It has been possible by knowing that operations of O&G industry performed offshore can be subdivided in three main activities: Well Engineering, Logistics and Production.

According to Miura (2004) "Well Engineering refers the junction of two major areas of expertise on the O&G industry. Those areas are Drilling and Well Operations and its focus is Well Construction and Repair, where operations of Drilling, Completion and Workover are involved".

The context of Well Engineering is more distinguishable in. The figure reveals the differences between well engineering, well operations and well construction previously mentioned by Miura (2004).

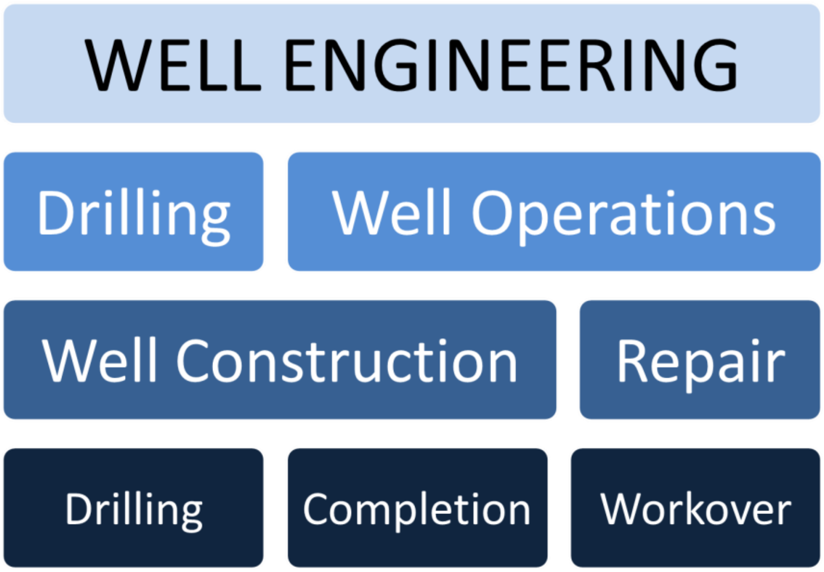


Figure 2.5 Well engineering illustrative definition.

The interest to focus on well construction is due to the benefit that this activity generates in the development of petroleum fields. According to Miura (2004) "large production increases are frequently related to the entry of a new production well or the restoration of wells with productivity problems".

Conscious on the importance that well construction represents to the O&G industry, this work aims to acquire knowledge from Safety Alerts involved and find the best way to disseminate it to avoid the recurrence of undesirable events. Up to this point BSEE's database has been presented, the meaning and importance of well engineering has been elucidated.

The other database used in this work composed by doctoral thesis and master dissertations is described below.

b) CEP-UNICAMP's Database

Doctoral thesis and master dissertations from the University of Campinas (UNICAMP) concerning to the Graduate Program of Petroleum Science and Engineering (CEP) is the second database selected by the author.

CEP proceed from the integration of petroleum engineering and geo-engineering of reservoir, considering the activities of geology, geophysics and engineering of reservoirs, well engineering, O&G production (marine and land systems) and oil field management.

According to CEP (2015), professors and graduate students are responsible for substantial improvements in science, technology and research in Brazilian petroleum industry.

CEP is interdisciplinary conformed by the Faculty of Mechanical Engineering (FEM) and Geosciences Institute (IG). Encompassing different research areas:

1) Reservoirs and Management:
   - Reservoir engineering.
   - Geo-engineering of Reservoir.
   - Geophysics of Reservoir.
2) Exploitation:
   - Well engineering.
   - O&G Production.
   - Petroleum Marine Systems and Risers.

CEP-UNICAMP database used in this work contain 455 documents. There are more documents concerning doctoral thesis and master dissertations of CEP but at the time to perform this work only those documents were visible in UNICAMP.BR (2015).

This database should be the first one consulted by the CEP students of UNICAMP when trying to conduct new investigations. One of the main challenges faced by the students is the access to the most important information which is in the content.

The information of author, advisor, keywords, title and thesis/dissertation defense date from CEP-UNICAMP's database are considered explicit knowledge because they are visible. As shown in Figure 2.6 that the information is required by the UNICAMP's search engine to perform the quests. Additionally the content of the theses and dissertations, interrelationship and relevance of information are considered tacit knowledge of the database.

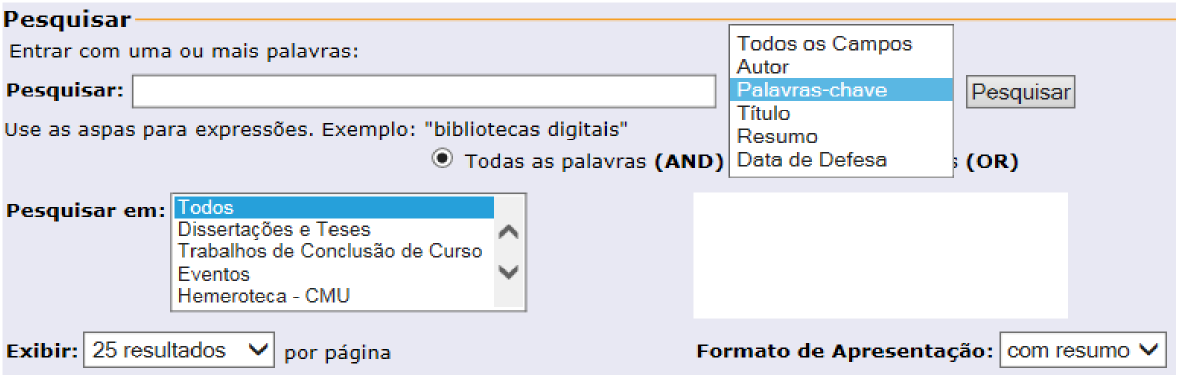


Figure 2.6 UNICAMP digital library's search engine.
Source: SBU, 2015.

In Section 4.2 a test performed with Master and Doctoral students of CEP will be presented. This test will allow to perceive the importance to make accessible the tacit knowledge of this database.

For both databases (BSEE's and CEP-UNICAMP's) content, interrelationship and relevance of information were considered as significant tacit knowledge. The following section presents an approach proposed by the author to determine the "relevance".

2.2. Concept of "Relevance".

The widely used term relevance can endorse various definitions. According to Stuckey et al. (2013) the meaning of this term is usually inadequately conceptualized and it might be explained because the notion of relevance is not a simple one.

According to Newton (1988) the meaning of relevance will depend on the importance that something has for someone.

Cuadra and Katter (1967) conducted an experiment with 140 judges to define the term relevance. These group defined these term as a product of explicit instructions and conditions; clarifying that the definition of relevance takes in count some particular considerations about judgment, documents, information statements and a particular criteria.

Therefore it was determined that relevance is function of several factors: interest, motivation, goal, objectives, target population, available information, society, among others.

For example, something considered as being relevant by a person without experience, could be considered irrelevant by an experienced person; information considered relevant in the area of reservoirs might not be equally relevant in the area of exploitation, and so on.

Consequently, this term has been adapted to the context of this research taking in count the following aspects of each database:

- BSEE's database contains knowledge about safety considered relevant to people that works in offshore platforms. But it was realized that some information of it could be more or less relevant for different persons according to the work that everyone performs. Therefore find relevant information could be easier if the needs of potential users be known. Three potential users of this information where considered, technical staff beginners, operational staff and data analysts.
- CEP-UNICAMP's database contains relevant knowledge in two areas, reservoir and exploitation. It should be the first database consulted by people who study at this university. But one more time, the relevant information for one student could be considered irrelevant by another; in this case, the necessity of information is more specific and highly dependent on the line of investigation of every student.

Differently from the above mentioned, when we talk about local and specialized databases, relevant information not only depends of the user's concerns, it also depends on the knowledge provided by experienced people (the content of the documents). Therefore the frequency in which the same information is mentioned in documents could be useful to determine how relevant it is for specialists.

In this work is proposed an approach to determine the relevance, considering the aspects above mentioned. This approach should allow finding not only relevant information according to the users concerns but also information considered relevant for a group of experts.

TF-IDF is employed by PhDic to calculate the relevance. However Shannon's entropy and Pareto's principle were taken into account to replace the relevance of PhDic under the considerations described below.

- **TF-IDF**

TF-IDF is the criterion used by PhDic to determine the relevance of words and concepts in a database. Take note that concepts are semantic definition of a word or a set of words (Guilherme, 1996).

TF-IDF is well known in the area of knowledge discovery. It evolved from the concept of IDF proposed by Jones (1972, 2004) which assumes that "the importance of a term relative to a document, is inversely proportional to the frequency of term occurrence in the database".

The Eq. 2.1 is a classical formula of TF-IDF used for term weighting (Zhang et al. 2011).

$$w_{ij} = tf_{ij} * \log\left(\frac{N}{df_i}\right) \quad \text{(Eq. 2.1)}$$

Where,

- w_{ij} is the weight for a term i in the document j;
- f_{ij} is the frequency of term i in document j;
- N is the number of documents in the database; and
- df_i is the document frequency of term i in the database.

TF-IDF is widely used for knowledge discovery, especially in text mining. However it is criticized for being 'ad hoc' (Ramos, 2000) because it is not directly derived from a mathematical model, although it could be explained by Shannon's information theory (Caropreso et al. 2001).

For that reason, in this work, Shannon's entropy was considered to estimate the relevance of words and concepts in the text mining process (see Section 2.3). Shannon`s Entropy is elucidated below.

- **Shannon's Entropy**

Shannon and Weaver (1963) present a mathematical theory of information, which states that entropy is the sum of all probabilities of occurrence of determined event, multiplied by its own logarithm, as displayed in Eq. 2.2 and Eq. 2.3.

$$H = -K\sum_{i=1}^{n} p_i \log p_i \quad \text{(Eq. 2.2)}$$

Where:

$$pi = {Freq_i}/{Freq_{\max} + 1} \quad \text{(Eq. 2.3)}$$

The Eq. 2.3 is used to calculate the probability of occurrence of the event i, where $Freq_i$ is the frequency at which i occurs and $Freq_{\max}$ is the frequency at which the most recurrent event occurs.

The Eq. 2.2 is used to calculate Shannon`s entropy, where p_i is the probability of occurrence of the event i and K is a constant that also affects the base of the logarithm; K could assume the values of 2 or e. When $K = 2$ the information is measured in bits, and when $K = e$ information is measured in nats (Barnett, 2009).

Note that bits and nats are units of information. In this work bits will be the unit used. Thus, K will assume the value of 2.

The Shannon mathematical theory of communication is also important to mention two powerful theorems noiseless coding theorem and the noisy-channel coding theorem. Those theorems deal with redundancy in communication signals and the extent to which it should be included.

Both theorems are explained below according to examples used in Barnett (2009).

Noiseless coding theorem allows to quantify the existing redundancy in messages and to know how much a message can be shortened or compressed and still be interpreted without error. An example of message without redundant characters is presented below.

Example 1: “TXT MSSGS SHRTN NGLSH SNTNCS”

The original message of the first example is “Text messages shorten English sentences”. The example can be understood without much difficulty, even eliminating the vowels that were considered redundant information. From this example is possible to admit that messages are still understandable if redundant information is eliminated. But in a case where noisy information exist, eliminate all redundant information could represent a problem. It is discussed in the following theorem.

Noisy-channel coding theorem concerns about how much redundancy is needed in a message to be understood without problems, even if noisy information exists. One example is presented below for a better comprehension:

Example 2: “RQRS BN MK WSAGS NFDBL”

This example is unlikely to be understood, because the original message was compressed (i.e. redundancy was eliminated) and noise was introduced (i.e. errors, five letters that do not correspond to the original message).

The same message was rewritten adding some redundancy in example 2.1.

Example 2.1: “EQRORS BAN MAKE WESSAGIS UNFEADCBLE”

The original message of examples 2 and 2.1 is: “Errors can make messages unreadable”. Regarding those examples is possible to notice that this theorem uses redundancy to combat noise. Observe that the added redundancy favored the comprehension of the original message.

The Shannon's entropy and their theorems were used in this work to find relevant concepts and discard noisy information. But a problem surged when trying to determine the boundaries between noisy and relevant information.

No material about determination of limits between relevant information and noise was found, because as mentioned at the beginning of Section 2.2, relevance depends on several factors. However, Pareto's principle was considered as a criterion to delimit relevant and noisy information. This principle is explained below.

- **Pareto's Principle**

Pareto's principle also known as 80/20 Principle has been generally used to raise efficiency in several industries (Koch, 2011). This principle became from Pareto's (1896) discovery as regards that 20% of the Italian population owned 80% of the lands and wealth, and from the observation that this pattern 80/20 was repeated consistently for different periods or different countries.

This principle has many applications in economics, business, software, health and safety, quality control, etc. Some quotes found on the literature about this principle are:

1) Approximately 80% of the land in Italy was owned by 20% of the population (Pareto, 1896).
2) In business: 80% of the sales come from 20% of the clients.
3) About texts: 80% of the value will come from 20% of the content.
4) In software engineering: 20% of the code has 80% of the errors.
5) In occupational health and safety: 20% of the hazards will account for 80% of the injuries.

Quotes 3 and 5 were adopted for this work. Quote 3 because this works aims to search for relevant content, so by relating Shannon's entropy and Pareto's principle is possible consider that the 20% of words and concepts with higher entropy are relevant.

Quote 5 has been also considered because one of the databases used are Safety Alerts from Offshore O&G Industry.

In this Section a concept of relevance applicable in the context of this work has been presented, this approach will be used to find relevant content of BSEE's and UNICAMP's databases. The following section will present how to access the content of big databases and determine its frequency of occurrence.

2.3. Text Mining

Text mining was considered as an alternative to search for content because it allows accessing the content of a big database and determine its frequency of occurrence.

Text mining techniques as well as data mining are used in a process called knowledge discovery. Text mining is multi-disciplinary technique that involves areas of informatics, statistics, linguistic and cognitive science. It aims to extract useful knowledge from non-structured or semi-structured data Aranha and Passos (2006).

Text mining, different from traditional search methods, allows finding unknown information (tacit knowledge). Traditional search methods, allows to find only known information (explicit knowledge).

The Figure 2.7 represents the basis of text mining process. It consists primarily on divide texts into smaller pieces taking advantage of the compositional character of the language, where the content of the database is the sum of the parts, most often called words or terms. Those parts are connected to each other through the syntax, semantic and statistics (frequency or relevance). Table 2.2 elucidates the meaning of the connectors used in Figure 2.7.

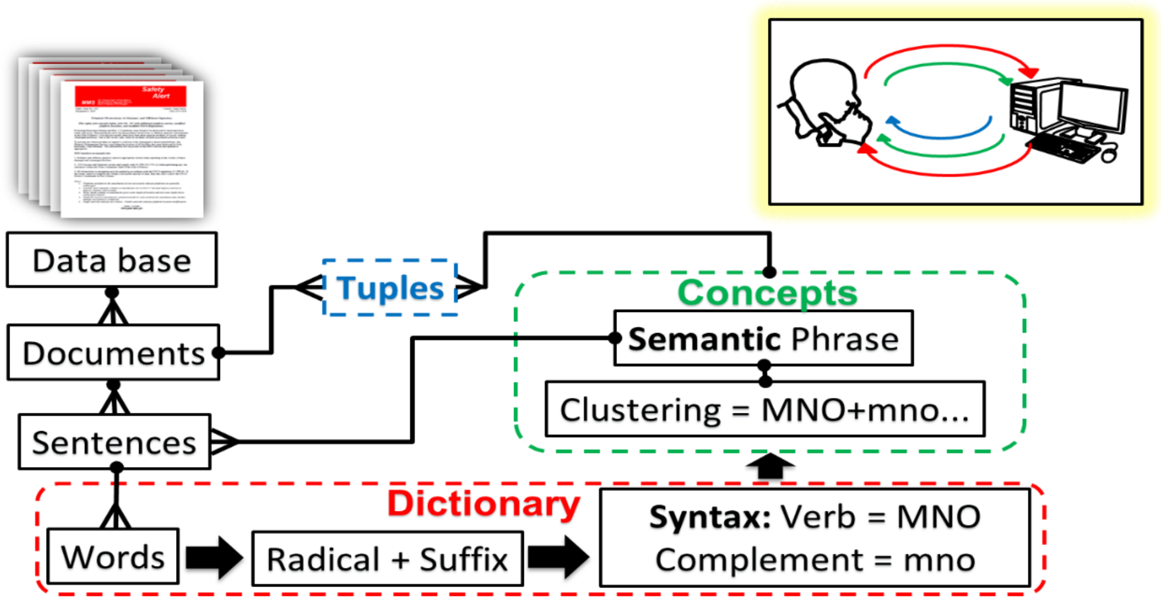


Figure 2.7 Text Mining Process.

Table 2.2 Connectors (Adapted from Palmer 1982).

Representation	Meaning
●—<	Relationship one-to-many
●—●	Relationship one-to-one

From Figure 2.7 can be observed that text mining is and interactive process performed between the user and a computational program. This process starts with a database that contains various documents, which in turn contain several sentences composed by several words. Each word could be divided in radical and suffix and this is the first result that the program presents to the user, a list of words classified by their radical and associates with their different suffixes. This first result is characterized in Figure 2.7 by the red arrow that goes from the computer to the user.

To each radical, the user should associate a syntax which may be MNO, mno, PQRmno&pqr, MNO&PQRmno&pqr, MNO&PQRmno&SRTpqr&UVWsrt&uvw, or PQRmno&SRTpqr&UVWsrt&uvw. For more information about this syntax see Miura (1992) or Guilherme (1996).

Obs: In this work has been used the simplest syntax of PhDic, that is MNO and mno. MNO represent key words, verbs, nouns, or even the 20% words with higher entropy (depending on the situation) and mno represent complements (words that are not verbs or nouns) it is words that could complement MNO or the 80% of words with lower entropy.

Until here, a dictionary of words is obtained, this dictionary shows words clustered by common radical, the frequency of occurrence of each radical and suffixes associated, and its associated syntax.

Subsequently, the program should cluster the words to each other according to the syntax previously designated (i.e. MNO + mno; verb + complement; or words with higher entropy + words with lower entropy) and the user should associate a semantic phrase to each cluster according to sentences contained on the documents of the database (this information should be displayed by the program to each clustering). Clustered words are also known as "arguments". With all this information a list of concepts is generated, this list contains the clusters of words (arguments), the semantic phrase (concept) and the frequency of occurrence of each cluster in the database.

Lastly, a list named tuples is generated.

Tuple is defined in Favarim et al. (2007) as a sequence of typed fields that given a $t = \{f_1, f_2, ..., f_n\}$, each f_i field can be real (value), official (name), wildcard (universal characters). In this case, "Tuples" is a list of documents associated with their own clusters, provided by the program.

As previously mentioned, to assist the text mining process of this work the computational tool PhDic has been used, it is described below.

- **PhDic**

PhDic is a computer-based tool developed by Guilherme (1996) based in the methodology proposed in Miura (1992). It is a hybrid system that uses connectionist models to build cognitive formalisms of knowledge representation.

Connectionist models allows associating structures, i.e. words or concepts, by processing symbols, i.e. letters or words. Those are frequently used in conventional search engines.

Cognitive formalism considers syntax, semantics and statistics to associate structures, i.e. words or concepts.

Note that words could be considered as structures or symbols depending on the processing step. When generating the dictionary, words are considered structures and to generate the list of concepts, words are considered symbols.

PhDic system is composed by three networks, as displayed in Figure 2.8:

- **Network of words** has the function to find significant words in the texts of the database and create a dictionary of words. A sample of a dictionary of words will be presented in Figure 2.10.
- **Network of phrases** associates words and creates a list titled “argument” (see Figure 3.4) using the words found in the network of words.
- **Network of texts** associates the arguments found in network of phrases with the documents containing them.

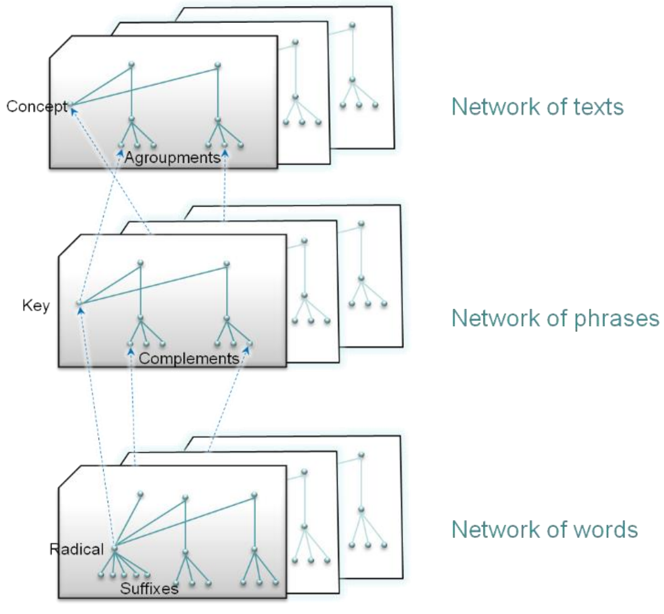


Figure 2.8 PhDic Networks.
Source: Miura (1992).

The first network of Figure 2.8 is the network of words. Its function is run all the texts and learn the most relevant words which are the input to the network of phrases. Network of phrases is responsible for finding the most relevant clusters of words in the texts which are used as input to the network of texts that is responsible for finding the possible patterns of texts (abstracts) in the database (Miura, 1992).

The interactive process between PhDic and the user is outlined in Figure 2.9 followed by a brief description.

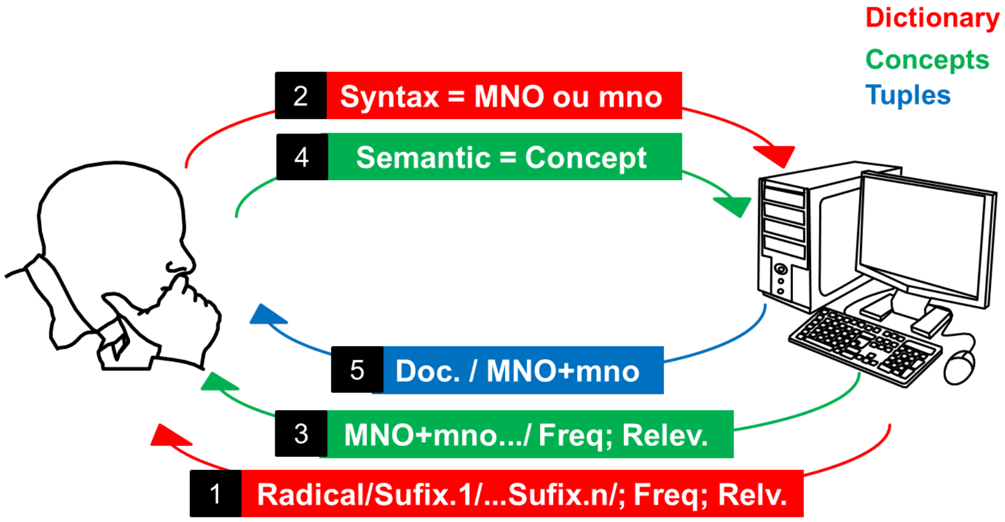


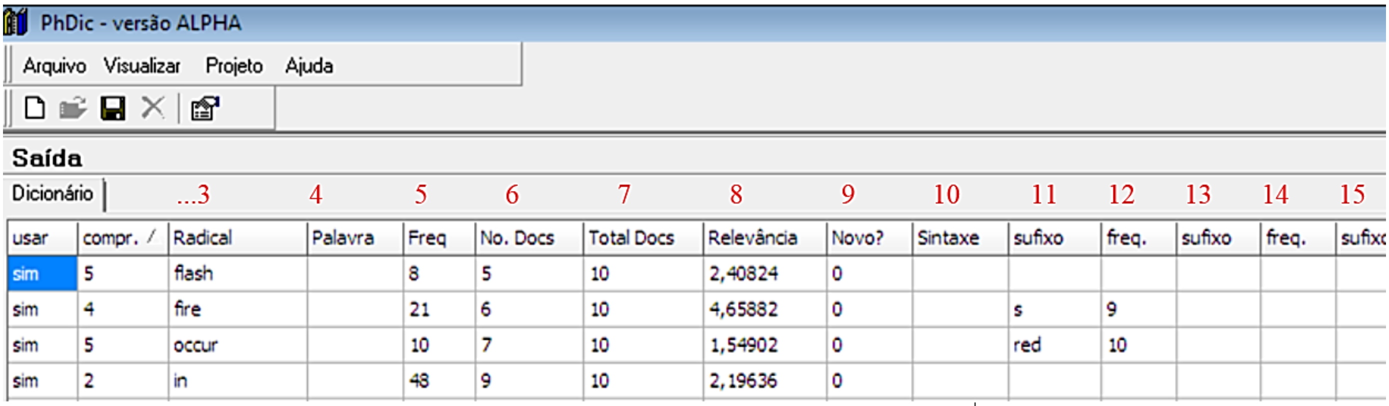
Figure 2.9 Interaction between PhDic and user during the text mining process.

The Figure 2.9 is an enlarged version of a part of Figure 2.7, placed at the right in the top of it. The Figure 2.9 displays the information obtained from PhDic and the information that the user provides to the program.

The meaning of each arrow presented in Figure 2.9 is described below:

Arrow number 1, “Radical/Sufix.1...” represents the first result obtained from PhDic. That is the dictionary of words presented in Figure 2.10 which contains the information described on this arrow. Radical is located in the third column of Figure 2.10, suffixes in columns 11, 13, 15, frequency of radical in column 5, and frequency of suffixes in columns 12, 14 etc., and finally Relevance in column 8.

Obs: The relevance provided by PhDic is calculated according to TF-IDF. It will be corrected during the application of the methodology.



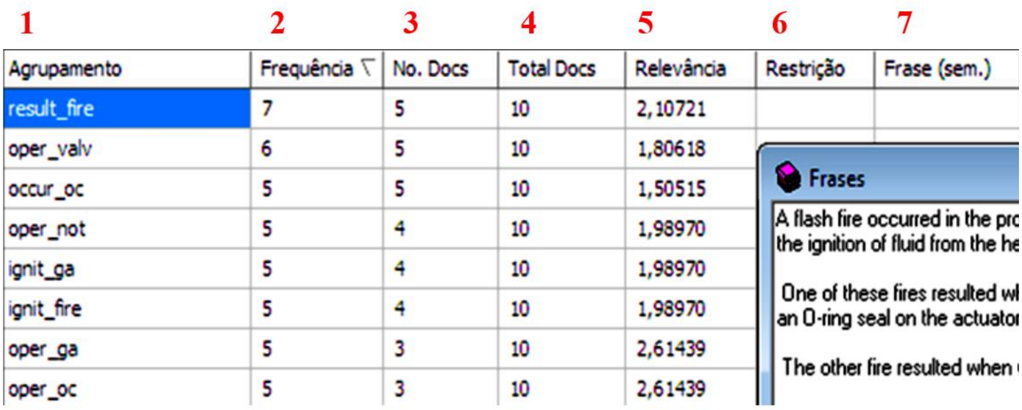
usar	compr.	Radical ...3	Palavra 4	Freq 5	No. Docs 6	Total Docs 7	Relevância 8	Novo? 9	Sintaxe 10	sufixo 11	freq. 12	sufixo 13	freq. 14	sufixo 15
sim	5	flash		8	5	10	2,40824	0						
sim	4	fire		21	6	10	4,65882	0		s	9			
sim	5	occur		10	7	10	1,54902	0		red	10			
sim	2	in		48	9	10	2,19636	0						

Figure 2.10 Sample of "Dictionary of words" furnished by PhDic.

Arrow 2 represents the information provided by the user, it should fill the column 10 of Figure 2.10. From this first interactive process a dictionary of words is obtained, it is the input to the following interactive process represented by the two following arrows.

Arrow 3 which goes from the computer to the user represents the next list denominated "list of concepts" that PhDic provides to the user. The information described in this arrow is the same in Figure 2.11. The clustering MNO+mno presented in the first columns of Figure 2.11, the frequency and relevance of this clustering is in the second and fifth column respectively.

Arrow 4 represents the information of semantic phrases that the user should provide to each cluster. Note from Figure 2.9 that semantic phrase can also be named "concept". Finally, the arrow 5 represent the information contained in the last list that PhDic provides to the user, this list is presented in Figure 2.12. The word "Doc" displayed in the Figure 2.9 represents the first column of Figure 2.12, and MNO+mno the second column.



Agrupamento 1	Frequência 2	No. Docs 3	Total Docs 4	Relevância 5	Restrição 6	Frase (sem.) 7
result_fire	7	5	10	2,10721		
oper_valv	6	5	10	1,80618		
occur_oc	5	5	10	1,50515		
oper_not	5	4	10	1,98970		
ignit_ga	5	4	10	1,98970		
ignit_fire	5	4	10	1,98970		
oper_ga	5	3	10	2,61439		
oper_oc	5	3	10	2,61439		

Figure 2.11 Sample of "List of concepts" furnished by PhDic.

	A	B
1	**Documento**	**Agrupamento**
2	SA_002	Drilling_Blowout
3	SA_002	occur_facil
4	SA_009	result_platform
5	SA_089	flash_fire
6	SA_089	ignit_fire

Figure 2.12 Sample of “Tuples” furnished by PhDic.

With the information presented in this section will be possible to access the contents of the databases. The next section presents valuable information about the possibilities to represent this content in interesting and useful ways.

2.4. Data, Information and Knowledge Visualization

This section presents the definitions of data, information and knowledge in visualization and the differences between them. It will be useful to find the better way to represent and improve the dissemination of content acquired with text mining techniques. After we will define “visualization”.

Visualization could be understood as mapping data, information or knowledge to comprehensible illustrations (adapted from Ribarsky and Foley, 1994).

According to the definition presented in Section 2.1, visualization must be understood as a model of structured knowledge.

However, Chen et al. (2009) presents a study to differentiate data, information and knowledge in visualization and present their definition in computational space as displayed in Table 2.3.

Table 2.3 Definition of data, information and knowledge in computational space.

Category	Definition
Data	Computerized representations of models and attributes of real or stimulated entities.
Information	Data that represents the results of a computational process, such as statistical analysis, for assigning meanings to the data, or the transcripts of some meanings assigned by human beings.
Knowledge	Data that represents the results of a computer-simulated cognitive process, such as perception, learning, association and reasoning, or the transcript of some knowledge acquired by human beings.

Source: Chen et al. (2009)

This differentiation is proposed under the author's criterion but supported by the literature such presented below.

- **Data Visualization**

It uses graphics to represent data. The time the researchers would take to read data represented graphically would be shorter than the time they would use to assimilate the same information if it were represented in matrices (Friedhoff and Kiley 1990).

Some examples of graphics used for data visualization better known as data charts are shown in Figure 2.13.

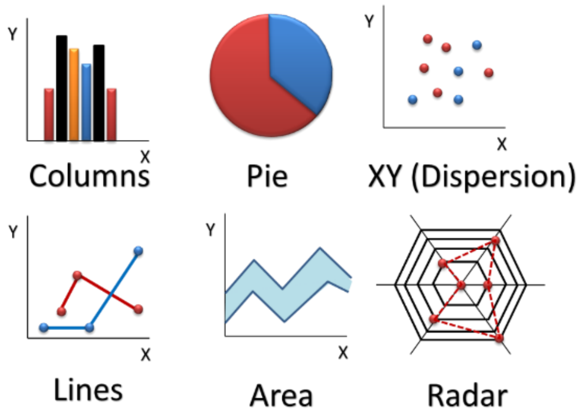


Figure 2.13 Data chart examples.

- **Information Visualization**

Information visualization uses interactive visual representations of abstract data to amplify cognition, it is usually performed with the help of programs (Card et al. 1999). Some examples used for information visualization are presented in Table 2.4.

Table 2.4 Examples of information used in visualization.

Information categories	Examples
Information about input data.	
• Abstract geometric and temporal characteristics.	Skeletons, features, events.
• Topological properties.	Contour tree for volume data, vector field topology, tracking graph for time-varying data.
• Statistical indicators and information measurements.	Histogram, correlation, importance, certainly, entropy, mutual information, local statistical complexity.
Information about the results.	Color histogram, level of cluttering.
Information about the process.	Interaction patterns, provenance.
Information about users' perception.	Response time, accuracy.

Source: Chen et al. (2009)

- **Knowledge Visualization**

Knowledge visualization must be understood as representing or structuring knowledge in a useful way to solve problems.

According to Chen et al. (2009) for knowledge visualization models, user's knowledge is indispensable. For instances the user might assign specific colors to different objects according to the domain. Moreover, different viewing positions should be chosen by the user, because the visualization results might reveal more meaningful information or problematic scenarios that requires further investigation.

The objectives of knowledge visualization includes sharing comprehension of a specialized area, reducing the complexity of knowledge acquisition. It improves the visualization of the community to learn, to model infrastructures for visualization and acquisition of knowledge (Chen et al. 2009).

Some examples for knowledge visualization presented in Chen et al. (2009) are Viewpoint mutual information, Pre-determined ranking, Ontology mapping (including tree maps and graphs, sizes and axes) and Workflow management.

In presented work the structures commonly used to visualize data, information and knowledge have been combined. In order to improve the dissemination and comprehension of knowledge and enhancing its applicability. The concepts shown in this chapter will be useful for understanding the proposed methodology to acquire and structure knowledge displayed in the following chapter.

3. METHOD TO ACQUIRE AND STRUCTURE KNOWLEDGE

The goal of methodology is let the database content visible, comprehensible and retrievable. The following chapter describes it.

The processes involves:

- **Knowledge Acquisition** is divided in two steps 1) Text mining and 2) Grouping and Relating concepts.
- **Filtering process** is not a mandatory step but it is useful to find documents in a particular area of interest.
- **Knowledge Dissemination** aims to structure the acquired knowledge in a way that is useful to the user.

From these processes is possible to acquire: explicit and tacit knowledge, specialized databases and structures of knowledge as displayed in Figure 3.1.

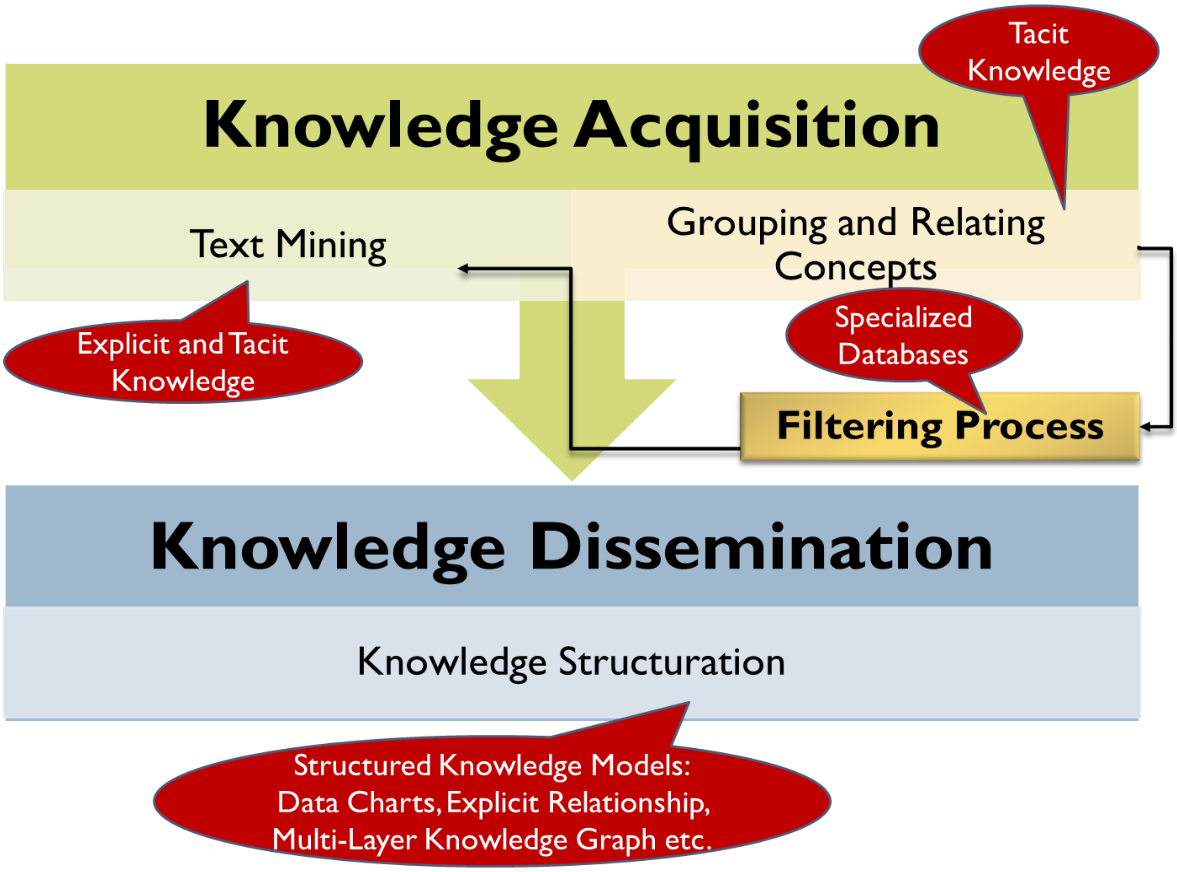


Figure 3.1 Results obtained on the different steps of the methodology.

This methodology could be applied in any database, as long as the database is local and specialized. As mentioned in previous chapters it has been applied in two databases.

For academic purposes the methodology will be described based on its application in BSEE's database to acquire and disseminate well construction knowledge. With this application is possible to prove that the methodology allows to extract and display relevant information from big databases according to the user's requirements.

Each process of the methodology and their respective results are detailed in the following sections:

3.1. Knowledge Acquisition

This process is divided in two steps: 1) text mining and 2) grouping and relating concepts. From the second step, the operation of "relating concepts" is not mandatory if it's known that the database will be filtered, as in the example presented to follow.

1) Text mining

The text mining process has been performed with the support of PhDic.

The results obtained during this process are explicit and tacit knowledge. They can be found in the Dictionary of words, list of concepts and Tuples obtained during the process. Text mining process and results are described below according to the information displayed in Figure 3.2 and to the description presented in Miura (2003).

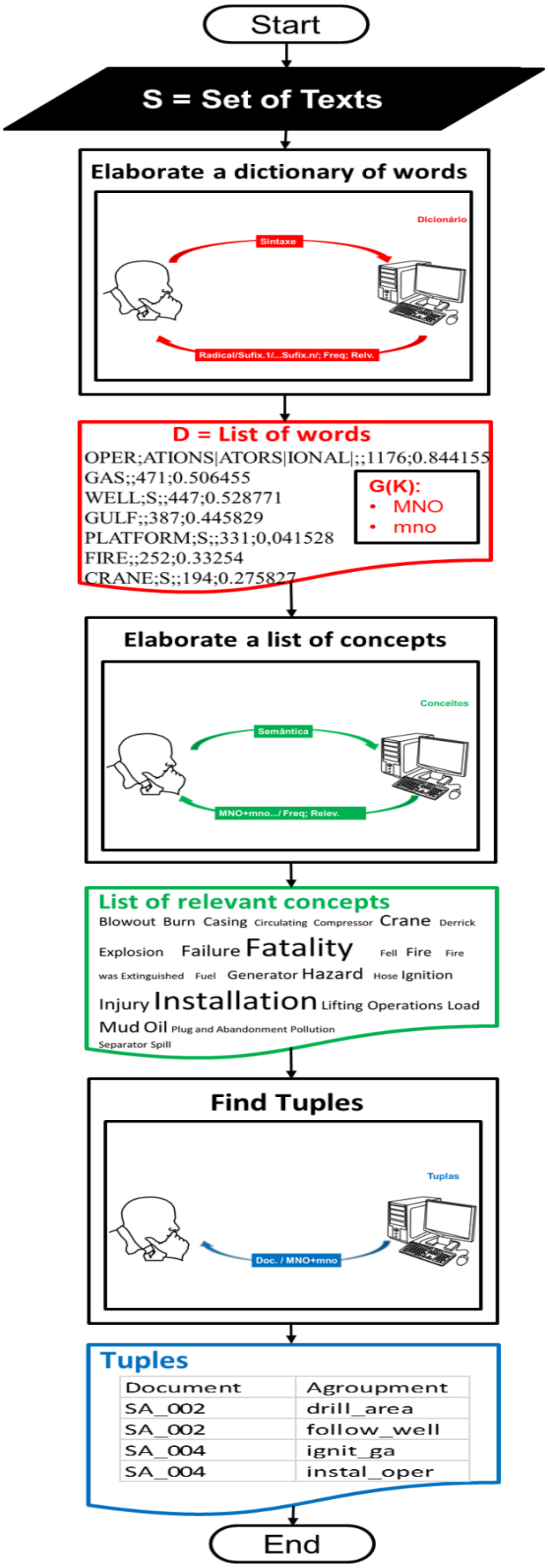
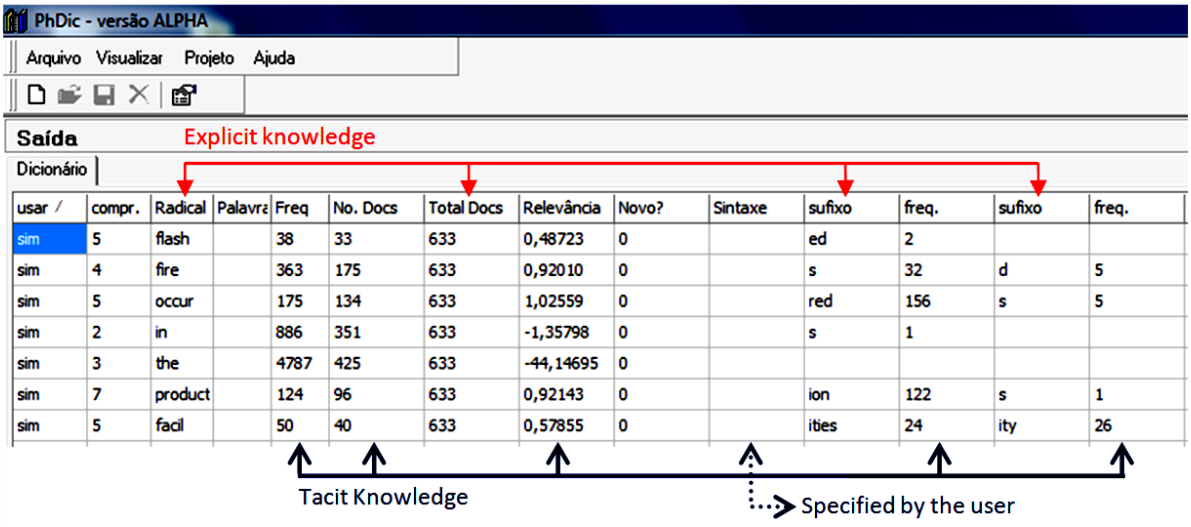


Figure 3.2 Text Mining Process with PhDic.

1. (User) Select a set S of texts to process (i.e. database). In this case S correspond to BSEE's database composed of 352 Safety Alerts;
2. Elaborate a dictionary of words. This is the first interactive process between the user and PhDic:
   a. (PhDic) Search for words in S generating a list D of words classified by radical and associated with their suffixes, frequencies and relevance (TF-IDF)
   b. (User) Correct the relevance from the list of words D (i.e. replace TF-IDF by Shannon's entropy), organize the words by relevance (the most relevant must always be on the top of the list), discard information that considers noise and select the words with a relevant meaning in the context of analysis. Finally give a grammar G for each word (G(K) specialist grammar). The specialist grammar in this step has been: MNO = verb or noun, and mno = words other than verbs or nouns.

As a result of this interactive process the dictionary of words D is generated (Figure 3.3). Note that in this application the dictionary of words generated encompasses information of safety in Offshore O&G activities, but it should vary according to the content of the database used.



usar	compr.	Radical	Palavra	Freq	No. Docs	Total Docs	Relevância	Novo?	Sintaxe	sufixo	freq.	sufixo	freq.
sim	5	flash		38	33	633	0,48723	0		ed	2		
sim	4	fire		363	175	633	0,92010	0		s	32	d	5
sim	5	occur		175	134	633	1,02559	0		red	156	s	5
sim	2	in		886	351	633	-1,35798	0		s	1		
sim	3	the		4787	425	633	-44,14695	0					
sim	7	product		124	96	633	0,92143	0		ion	122	s	1
sim	5	facil		50	40	633	0,57855	0		ities	24	ity	26

Figure 3.3 Explicit and Tacit knowledge from a sample of "Dictionary of words" obtained by PhDic.

The explicit knowledge obtained from the dictionary corresponds to: radical, total of documents analyzed, and suffixes. This kind of information could be easily found by using traditional methods.

Tacit knowledge in this result refers to: frequencies of radicals and suffixes, the relevance and the syntax that should be specified by the user.

3. Elaborate a list of concepts. It is the second interactive process:
   a. (PhDic) Using the dictionary of words the set of texts is processed again, this time to find clustering of words (denominated arguments by PhDic) in the texts according to the specialist grammar G(K). Then the list of arguments with its respective frequency of occurrence is generated.
   b. (User) Correct the relevance from the list of arguments, selects the arguments with relevant meaning (i.e. the 20% of clusters with higher entropy). In this step, the expert can refine the grammar or manually adjust the arguments to generate a list of concepts. For example, implementing the negative form of some words in the list, adding or eliminating them (i.e. change MNO+mno to MNO or mno, or even to **MNO+mno+mno**). Moreover, the user associates each clustering to a semantic phrase according to its meaning in the database (e.g. to the clustering "result_fire", the semantic phrase is "Fire resulted from ignition of fluids")

As result of this interactive process, the list of concepts containing relevant words or clusters of words (20% with higher entropy) that have a strong meaning in the analyzed context is generated. In this case this list is about safety in offshore O&G industry.

This result has been obtained with the help of PhDic by associating radicals according to the syntax specified by the user in the dictionary (see Figure 3.3). A sample of this list is presented in Figure 3.4, explicit and tacit knowledge are also identified.

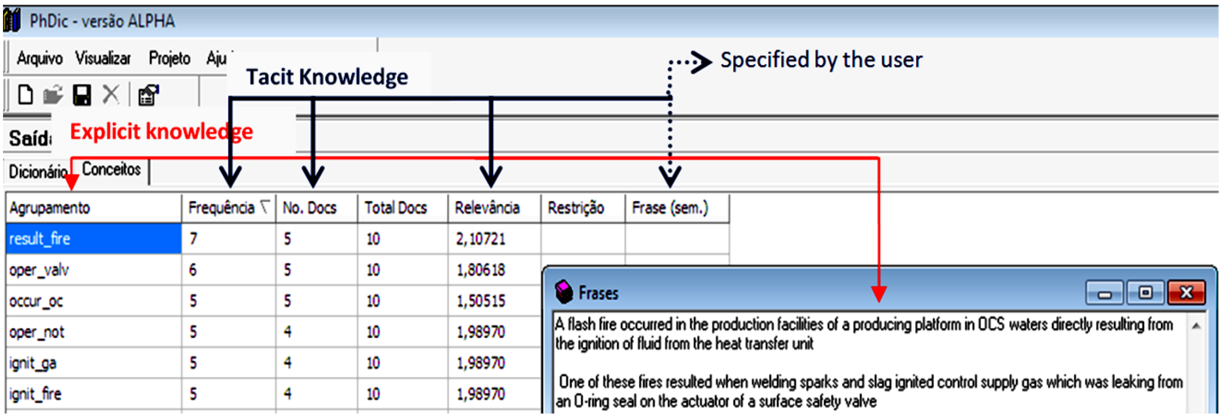


Figure 3.4 Sample of list of concepts furnished by the PhDic.

In this case, clustering and phrases were taken in count as explicit knowledge, while frequency, number of documents, relevance and semantic phrases were assumed as tacit knowledge.

Note that in dictionary of words the information of "No. Docs" is classified as explicit knowledge and inside the list of concepts it is classified as tacit knowledge. Because is possible to find one word in the database using traditional searching methods but it is very difficult to find two words with the same meaning contained in the sentences of a big database.

4. Find Tuples. This information is furnished by PhDic to the user.
   a) (PhDic) Process the set of texts again, using the list of concepts generated in the previous step, this time to find the documents containing relevant arguments.

The result obtained in this stage is "tuples" that is a list of documents associated to clusters of words which belong them.

A sample of this list is presented in Table 3.1. Recall that one argument can be repeated in the one or more documents of the database. It helps to determine the main subject of the document or database. The information document and arguments are considered explicit knowledge.

Table 3.1 Sample of Tuples furnished by PhDic

Documents	**Arguments**
SA_002-ShallowDrillingHazards.txt	drill_case
SA_002-ShallowDrillingHazards.txt	drill_while
SA_002-ShallowDrillingHazards.txt	drill_pipe
SA_002-ShallowDrillingHazards.txt	drill_well
SA_002-ShallowDrillingHazards.txt	drill_well
SA_002-ShallowDrillingHazards.txt	drill_well
SA_004-FlashFireCuttingandWelding.txt	ignit_ga
SA_004-FlashFireCuttingandWelding.txt	instal_oper
SA_004-FlashFireCuttingandWelding.txt	extinguish_fire
SA_004-FlashFireCuttingandWelding.txt	extinguish_fire
SA_004-FlashFireCuttingandWelding.txt	extinguish_fire
SA_004-FlashFireCuttingandWelding.txt	occur_fire

Observe that in stages A and B the information should be refined. The refining process consists eliminating noisy information and finding relevant information.

To clarify the meaning of relevance, that is the 20% of words or arguments with higher entropy (according with Section 2.2), the Figure 3.5 presents a sample of arguments vs. frequency and the Figure 3.6 presents the frequency vs. relevance of the same sample of words.

Figure 3.5, in addition to the frequency of occurrence of a sample of arguments, presents three information zones:

- Zone I: this zone contains the information that occurs more frequently in the database. Is considered that this zone encloses trivial information because it generally contains widely known information, which do not shows benefits to improve knowledge acquisition.
- Zone II: this zone presents interesting information potentially innovative. In the application of the methodology in BSEE's database, information of Safety Alerts about causes, consequences and recommendations to prevent the occurrence of undesirable events have been obtained from this zone.
- Zone III: this zone presents less frequent information contained in the database, this information could correspond to emerging researches, poorly known information or typing errors.

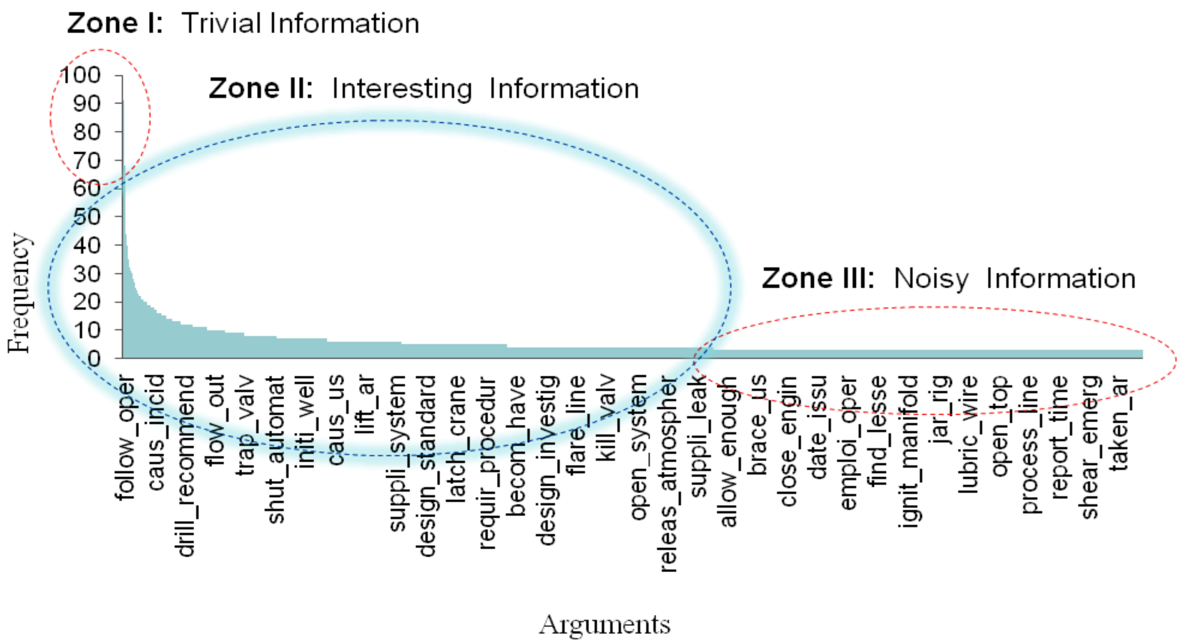


Figure 3.5 Frequency of a sample of arguments.

The Figure 3.6 is a representation of the relationship between frequency and Shannon's entropy. The figure allows to notice that the information corresponding to Zone II of Figure 3.5 has higher entropy than the information corresponding to Zone I and Zone III. By applying the Pareto's principle on this graph is possible to determine the most relevant information that is represented by a blue rectangle in the Figure 3.8.

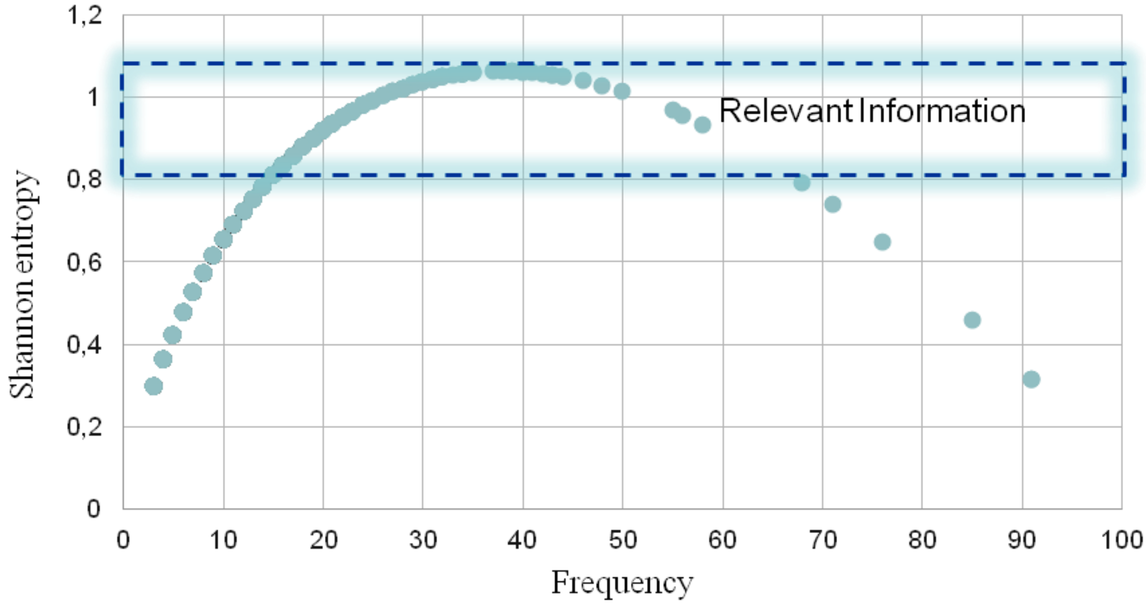


Figure 3.6 Frequency vs. Shannon entropy of a sample of arguments.

After determining the most relevant arguments, the concepts corresponding to those arguments should be analyzed and grouped and related.

Obs: If the information required by the user is not restricted and the filtering process is not required, the process of grouping and relating concepts should be carried out one after the other. In this case the sequence of these processes is grouping concepts, filtering process and then relating concepts process.

2) Grouping Concepts

This task is performed with the information of the list of concepts generated in text mining process, according to mutual characteristics or definitions that encompasses several of those concepts.

For this application (BSEE's database) concepts were grouped according to the definitions presented in the Table 3.2.

Table 3.2 Definitions of Groups.

Accident or incident:	It is any unplanned and undesirable event which caused or has the potential to cause personal injuries or healthy problems, damage or loss of property, facilities or environment.	
Cause or Condition:	Something that precedes a phenomenon. Something or someone that makes something happen or exist.	
Consequence:	Something that happens as a result of a particular action or set of conditions. The result of an accident.	
Operational Environment:	Environment or place where operations are performed (e.g. Drilling Platform).	
	Environmental Component:	Objects, equipment, devices etc. belonging to an operational environment.
Operation:	Procedure performed with the aim of construct the well. This involves operations in drilling activities, completion and workover.	
Other:	None of the previously described.	
	Fluids:	A continuous, amorphous substance, not solid, whose molecules move freely and pass from one to another recipient assuming the shape of its container. They are related to well construction.
	Parameters:	Set of measurable factors such as temperature, pressure etc.
	Personnel:	People who work for a company or organization.
Document:	Related to Safety Alerts.	

(Definitions of each group have been established based on definitions found on: Glossary of HSE terms, Aurélio Dictionary and Merriam-Webster dictionary).

Note that Table 3.2 is composed by seven main groups, and some of them have subgroups. It happens because according to the information presented in Chapter 1 the human being can remember seven plus or minus two things. Therefore, the general information of the database should be divided into seven plus or minus two groups which could be separated in other seven plus or minus two subgroups and so on. The author suggests to take into account this theory in future works.

Using the information grouped of BSEE's database was possible to map four operational environments presented in the Figure 3.7 This information was used to filter the data and found Safety Alerts about Well Engineering operations

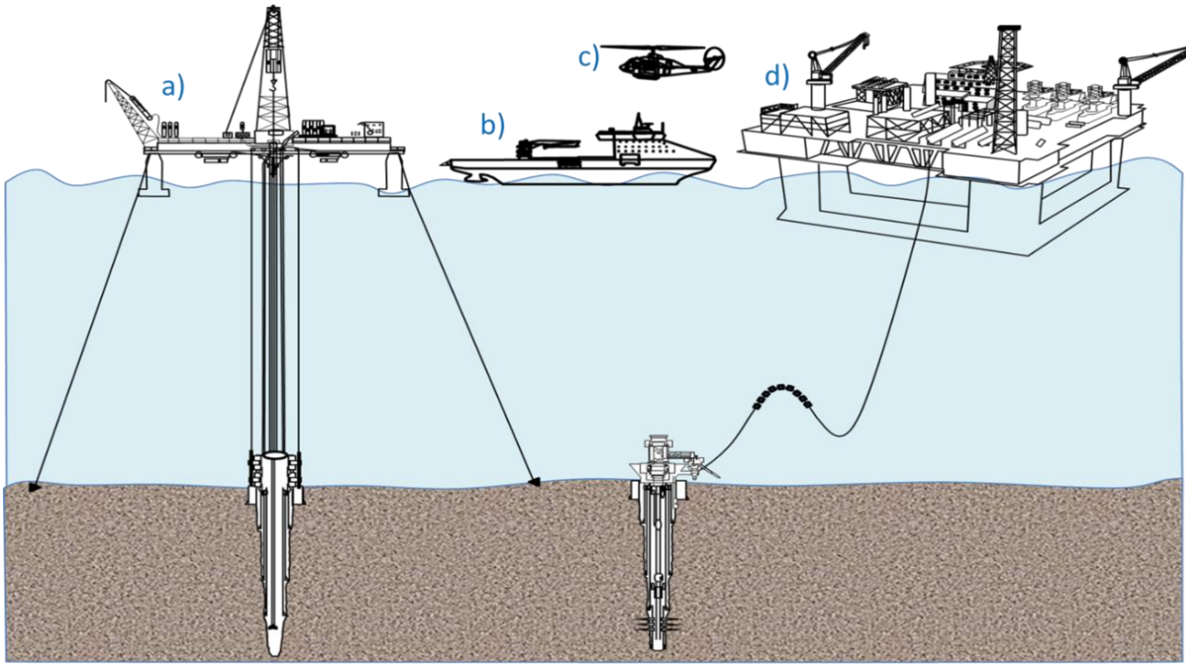


Figure 3.7 Operational Environments found in BSEE's database concerning Offshore O&G Industry. a) Drilling Platform, b) Supply Vessel, c) Helicopter, d) Production Platform.

Figure 3.7 presents four operational environments found in BSEE's database, that are drilling platform, supply vessel, helicopter and production platform. This information has been considered to execute the filtering process in order to obtain well construction data that is the required information. The following section explains how the filtering process has been performed.

3.2. Filtering Process

If the database contains various subjects and the user is looking for specific information, a filtering process can be performed. The process consists in use key concepts found in the text mining process.

"Key concepts" are one or more words that represents an idea that could be easily understand in a particular area of study. In this example key concepts belonging to the group of operational environment will be used in the process.

Concepts belonging to the group of operational environment are: drilling platform, supply vessels, helicopter, and production platform. Before explaining the filtering process, the reason for choosing these group is clarified.

Obs: Synonyms of these concepts were also considered as the same concept or as a subgroup of the concept, for example “Offshore Drilling Platforms”, “Jackup” and “Drilling Ring” were also considered as to being “Drilling platform”. Note that “Jackup” could be also considered as a subgroup if a work with more details be required.

Different operations could be performed from these operational environments. From drilling platforms, well construction operations could be performed. Repairs or logistic activities are performed from supply vessels and helicopters. And production activities are executed from production platforms.

Note that supply vessels and helicopters are also used in well construction or production activities but just occasionally.

Therefore it is expected that using the key concepts in the filtering process, the database could be separated in:

A. documents concerning well construction activities;
B. documents concerning repairs and logistic;
C. documents concerning production activities.

After clarifying the reason of choosing the group “operational environment”, the filtering process illustrated in Figure 3.8 can be described.

Figure 3.8 represent the entire process performed to filter BSEE’s database.

Observe that the two first steps, refer to the processes described in Section 3.1. (Text mining process and grouping concepts). After those steps, the question “Do you want to filter the database?” should be answered by the user to perform or not the filtering process.

It is necessary to clarify that the filtering process is not a mandatory step for the methodology, but it is advantageous when the user is looking for relevant content of a specific topic (e.g. well construction is the issue of interest in example). Because one concept can be more or less relevant depending on the context and the results are presented in Figure 3.12.

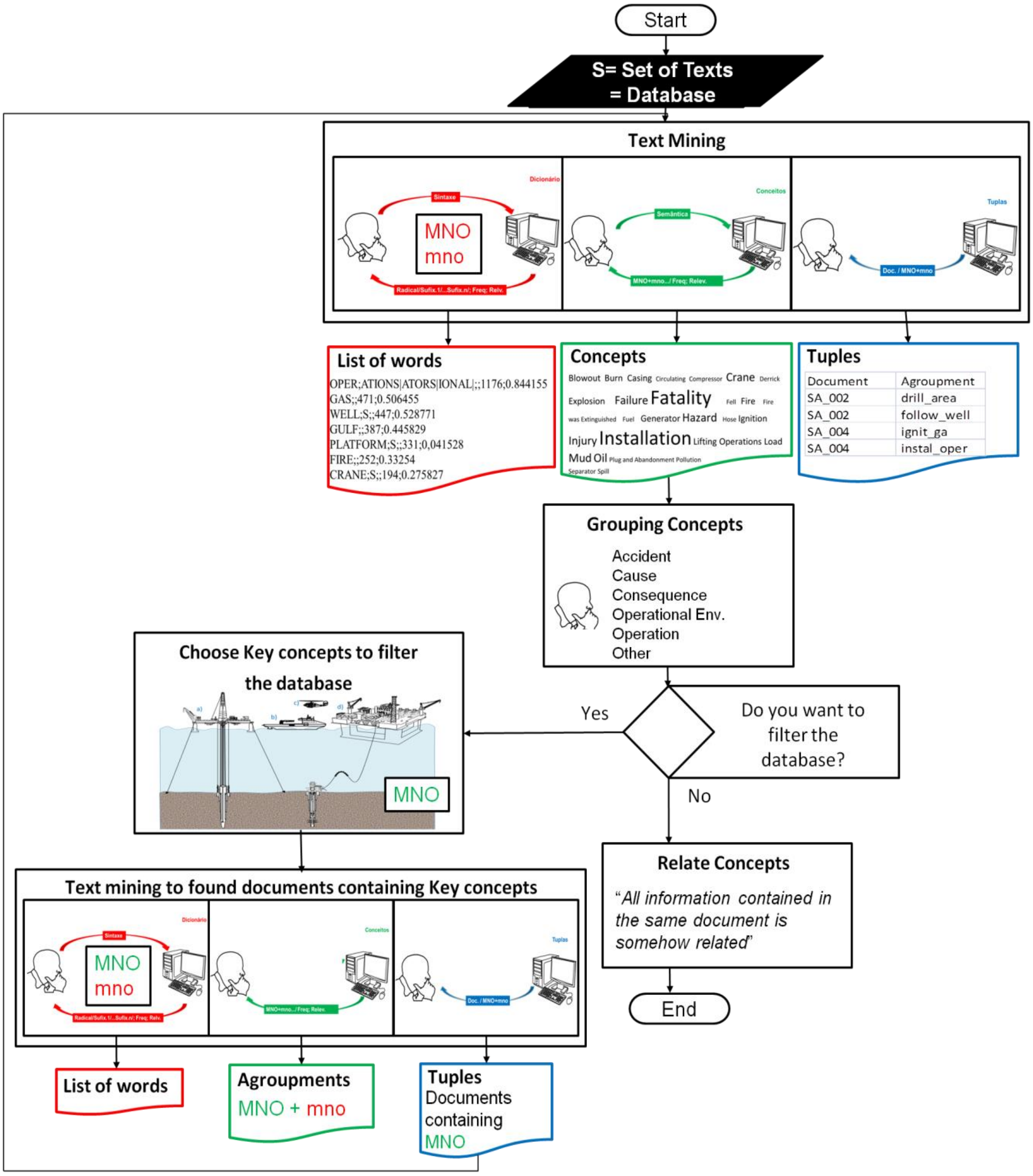


Figure 3.8 Filtering Process performed with PhDic.

The explanation of Figure 3.8 is described below.

1. (User and PhDic) perform the text mining process as explained in Section 3.1.
2. Results of text mining process are obtained (i.e. Dictionary of words, List of concepts and Tuples).
3. (User) Group the concepts from the "List of concepts" according to its definition presented in Table 3.2.

4. (User) Answer the question: “Do you want to filter the database?” in this case the answer is “Yes”.
5. (User) Choose Key concepts to filter the database (i.e. MNO). The concepts used in this example were “drilling platform”, “supply vessels”, “helicopter”, and “production platform”.
    - To obtain the “Well construction” database, the key concept “Drilling Rig” and synonyms were chosen as MNO in the G(K) of the dictionary acquired in the first text mining process, other words were classified as mno in the G(K). After PhDic clusters every MNO with each mno belonging to the database tuples are generated. From the list of tuples, the user obtains the information of the databases containing MNO that in this case is “Drilling Rig” and synonyms. It is the “well construction” database. The same process has been performed to acquire the other databases but using their specific key concepts.

Note from this process that the user didn’t analyze the information or relevance because the process was performed only to find the documents containing key concepts chosen.

With the key concepts mentioned were acquired the three expected databases and one unexpected:

- Well Construction database A containing 232 documents.
- Repair and Logistic database B containing 130 documents.
- Production activities database C containing 253 documents.
- Unknown database D with 6 documents

Figure 3.9 represents how BSEE’s database was separated. The yellow circle represents the database “A” concerning to well construction that was found using the key concept “drilling platform”. The red circle represents the database “B” concerning to repairs and logistic that has been found by using the key concepts “supply vessel” and “helicopter”. The blue circle represents the database “C” concerning to production activities that has been obtained by using the key concept “production platform” in the filtering process. Some documents that didn’t contain the key concepts previously mentioned are represented by a purple circle.

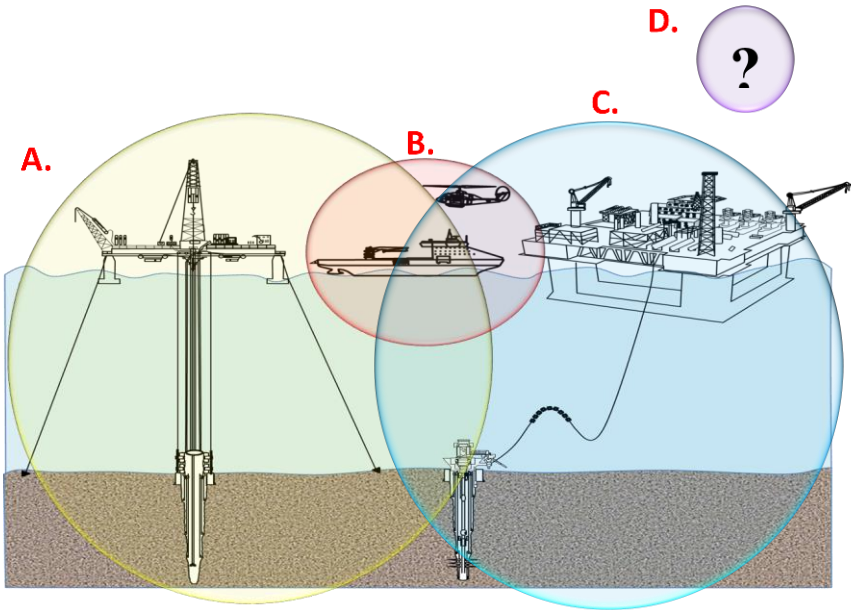


Figure 3.9 Representation of database separation according to key concepts of operational environment.

The last database containing six documents is an unexpected set of documents those 6 documents were analyzed and was discovered that their content describe certain type of accident without specifying the operational environment. The author considered these documents not relevant to the area of interest (well construction) and they were neglected.

In future studies, if a similar situation occurs, the user should read the documents and decide if they are relevant or not.

Note that the sum of the documents of A. B. C and D. is more than 352 which is the total quantity of documents of BSEE's database. This is because some documents relates similar accidents that took place in different operational environments (e.g. Fire that occurred in a Drilling platform and Fire occurred in supply vessel, both related with exhaust of gas and welding spark and both are described in the same safety alert because of their similarity). Then it is possible to affirm that the databases obtained during filtering process are related (see Figure 3.9).

The filtering process can be performed several times depending on the information required by the user, usually once is enough, but it will depend on the key concepts that the user choose.

6. (User and PhDic) text mining process has been applied again but this time on each database. As the example is about well construction, only these results will be demonstrated.

A sample of relevant concepts of well construction is shown in Figure 3.10 where the font size represents the relevance of each concept relative to others found on the database.

Figure 3.10 Sample of concepts. The size of letter represents the relevance of the phrase on the database context.

Figure 3.11 and Figure 3.12 present contrasts between frequent and relevant concepts of accidents found in both databases the general database concerning to offshore O&G industry and the specific database concerning to well construction activities.

The size of letter in Figure 3.11 represents the frequency of the concept in the database, as higher the letter higher the frequency of occurrence. In contrast in Figure 3.12 the size of letter represent the relevance.

Figure 3.11 Sample of frequent accidents found in the entire database and in well construction context.

Figure 3.12 Sample of relevant accidents found in the entire database and in well construction context.

From the comparison of Figure 3.11 and Figure 3.12 is possible to notice that relevance and frequency varies according to the level of information. In the safety alert database of offshore O&G activities the most frequent accident found is “Fire” and the most relevant accident is “Diverter Flow Event”. On the other hand the most frequent accident for well construction is “Blowout” but the most relevant accidents in both cases are “Riser Disconnect” and “Diverter Flow Event”.

Observe that most frequent concepts of BSEE’s database about accidents (fire and blowout) matches with the information widely recognized in the industry. Many attention is given to them in order to prevent its recurrence. However the most relevant accidents (diverter flow event, loss of well control, and riser disconnect) are poorly noted or recognized as latent risks especially by beginner staff.

After to find relevant concepts about well construction they should be related, this process is describes below.

- **Relating Concepts Process**

This process is performed based on the hypothesis that “All information contained in the same document is somehow related”. In other words, every concept has a direct relationship to other concepts belonging the same document and an indirect relationship to very other belonging the database. Figure 3.13 will help to clarify this idea.

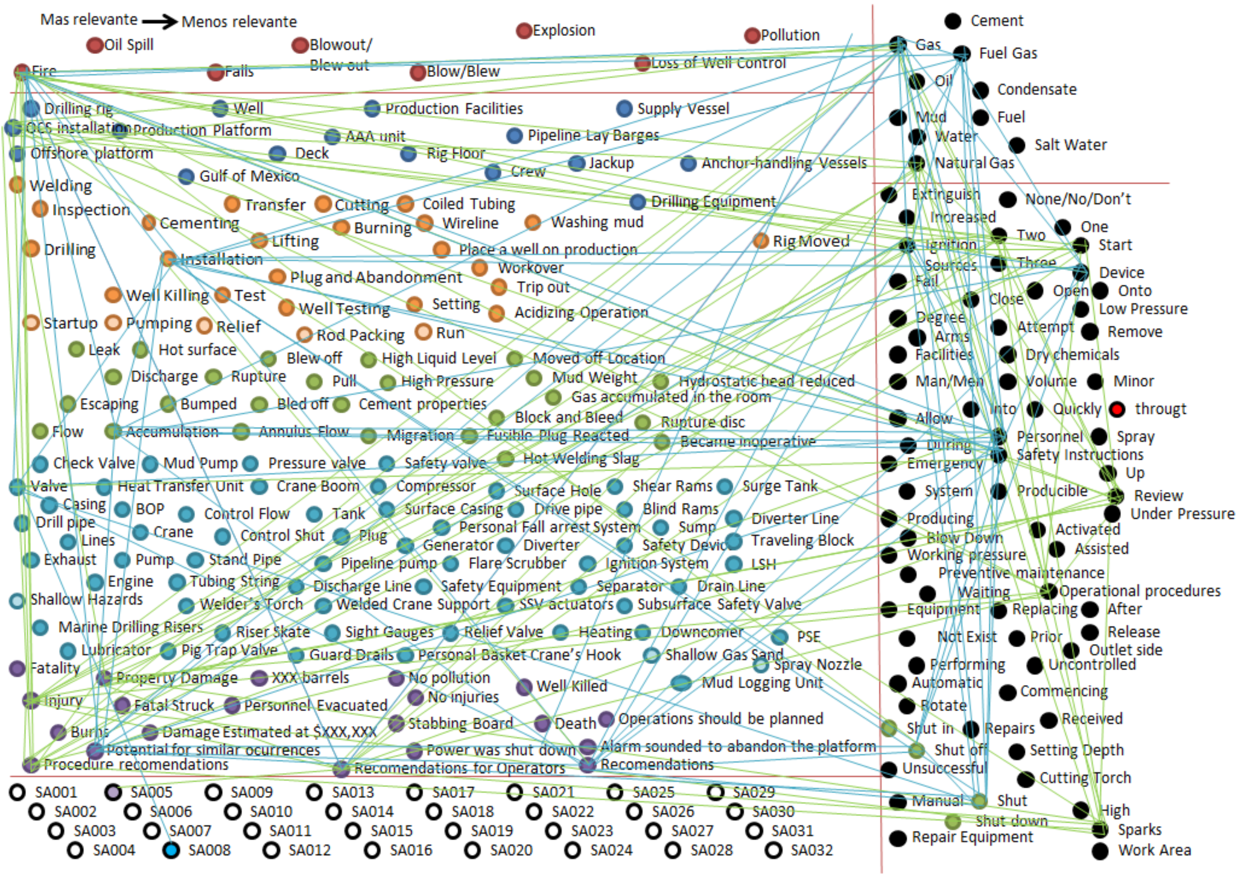


Figure 3.13 Sample of relationship between concepts of two documents.

The Figure 3.13 is a representation of relevant concepts found in BSEE's Database. Each point represents a relevant concept and the different colors of these points represent groups and subgroups of Table 3.1. The meaning of colors used in Figure 3.13 are:

- Red: incident or accident
- Blue and light blue: Operational environment and environmental components
- Orange: Operations
- Green: Cause or condition
- Purple: Consequences
- Black: Other
- White with black border: Documents.

The lines connecting different points represent the relationships between concepts. The light blue lines represent relationship between concepts of SA008 (Safety Alert No. 8) and green lines represent the relationship between concepts belonging SA005 (Safety Alert No. 5). Observe that some points are intersected several times and not only by one color of line it means that the concept related to that point exist in both documents and moreover, it appears several times on the document(s), the concept “Fire” shown in the upper left of Figure 3.13 is a clear example of it.

To find the relationship between concepts has been used a text editor and the following steps have been performed:

1) **Relate the concepts**, each concept found in the text mining process has been related to others belonging to the same document. An example is described below:

Imagine that Table 3.3 is a list of concepts (A, B, and C) belonging the same document (SA_1). By relating the concepts Table 3.4 will be obtained.

Table 3.3 Example of list of concepts related to belonging document.

Concept (C1)	**Document**
A	SA_1
B	SA_1
C	SA_1

Table 3.4 Example of list of concepts related to other concepts of the same document.

Concept (C1)	**Concept (C2)**	**Document**
A	B	SA_1
B	C	SA_1
C	A	SA_1
A	C	SA_1
B	A	SA_1
C	B	SA_1

The Table 3.4 shows how concepts are related, A is related with B and C; B is related with C and A; and C is related with B and A.

2) **Determine the frequency of each concept in the database,** in this step the information “Document” will not be taken into account.

Imagine that the frequency of occurrence of each concept in SA_1 is one (1), it is that each concept occurred only once in that document. Now imagine that the document SA_2 contains the concepts B, C and D and their frequency of occurrence is also one (1) as displayed in Table 3.5.

Table 3.5 Example of list of concepts related to other concepts of the same document, this example shows concepts of two documents.

Concept (C1)	Concept (C2)	Document	Freq.
A	B	SA_1	1
B	C	SA_1	1
C	A	SA_1	1
A	C	SA_1	1
B	A	SA_1	1
C	B	SA_1	1
B	D	SA_2	1
C	B	SA_2	1
D	C	SA_2	1
B	C	SA_2	1
C	D	SA_2	1
D	B	SA_2	1

Observe that in Table 3.5 exists associated concepts of SA_1 that are repeated in SA_2, then if the column "documents" be removed, the frequency of concepts related in the database could be determined, see Table 3.6.

Table 3.6 Example of list of concepts related associated to its respective frequency of occurrence in the database.

Concept (C1)	Concept (C2)	Freq.
A	B	1
B	C	2
C	A	1
A	C	1
B	A	1
C	B	2
B	D	1
D	C	1
C	D	1
D	B	1

Observe that in this example, the related concepts "B – C" and "C – B" has a frequency of occurrence of two (2), it means that the relationship of those concepts occurred twice in the database. Table 3.6 doesn't show which documents contain those concepts related but Table 3.5 does.

With this process is possible to find the relationship between documents of BSEE's database as displayed in Table 3.7. This table displays the information of:

- Group to which Concept (C1) belongs,
- Concept (C1),
- Concepts associated it is Concept (C2),
- The name of the document to which belongs both Concepts (C1 and C2),
- Frequency at which both concepts (C1 and C2) appear in the document.

Table 3.7 - Sample of list of related concepts and to the document they belong.

Group	**Concept (C1)**	**Concept (C2)**	**Document**	**Frequency (C1+C2) in Document**
Operation	While Drilling	Drilling	SA_002-ShallowDrillingHazards	2
Operational Environment	Drilling Rig	Drilling	SA_002-ShallowDrillingHazards	2
Operational Environment	Well	While Drilling	SA_002-ShallowDrillingHazards	1
Operational Environment	Well	Shallow Hazards	SA_002-ShallowDrillingHazards	1
Operation	Welding	Fire	SA_004-FlashFireCuttingandWelding	3
Operation	Train the Personnel	Fire	SA_004-FlashFireCuttingandWelding	3
Environmental component	Valve Actuator	Fire	SA_004-FlashFireCuttingandWelding	3
Consequence	Material Damage	Fire	SA_004-FlashFireCuttingandWelding	3

The Table 3.8 displays the information of:

- Group of Concept C1,
- Concept C1,
- Concept C2,
- Quantity of documents containing (C1+C2),
- Frequency of occurrence of (C1+C2) in the database,

From which Group of C1, quantity of documents containing (C1+C2) and their frequency of occurrence are considered tacit knowledge; and concept C1 and concept C2 are considered explicit knowledge.

Table 3.8 - Sample of list of related concepts according to the hypothesis.

Group of C1	**Concept (C1)**	**Concept (C2)**	**#Documents containing (C1+C2)**	**Frequency (C1+C2) in database**
Operational Environment	Drilling Rig	Drilling	31	82
Operation	Drilling	Drilling Rig	31	82
Operational Environment	Well	Gas	27	81
Fluid	Gas	Well	27	81
Operation	While Drilling	Drilling	26	81
Other	Extinguish fire	Fire	26	49
Cause or Condition	Ignition	Fire	26	61

In this section was explained how to relate concepts according to the documents content, how to discover the frequency and relevance of concepts in a database proving that relevance could vary according to the content thus, allowing find non obvious but significant information.

The relevant information obtained from BSEE's Safety Alerts has been structured in different models, for different scenarios to improve its dissemination. Those structured knowledge models are presented in the following section.

3.3. Knowledge Dissemination

With the information obtained in previous processes of the proposed methodology, was possible to structure the knowledge in three different ways employing visualization techniques.

Those structures were build considering the requirements of potential users for three different scenarios:

Scenario 1: For this scenario data analysts are contemplated as end users.

Data charts are the kind of structure used for this scenario. The data charts built compares the information of quantity of Incident Reports and Safety Alerts concerning the same incident (fatalities, injuries, loss of well control, spills ≥ 50bbls, fire/explosions) classified by year.

This analysis has been performed to determine the effectiveness that Safety Alerts had to avoid the recurrence of undesirable events. The process to build this first structure is described below:

- **Choose the variables,** for this example variables are:
  1) Type of incidents that were obtained from BSEE's website (this information is shown in Figure 2.4);
  2) Number of incident reports, also obtained from Figure 2.4;
  3) Number of Safety Alerts that were found by using the type of accidents as key concept in the lists of concept obtained in previous processes of the methodology;
  4) Year of publication of incident reports and
  5) Year of publication of Safety Alerts.
- **Build the structure,** data charts were used for this example with three axes, one structure is presented here (see Figure 3.14) to clarify the idea.

The Figure 3.14 is an example of how could be determined the effectiveness of Safety Alerts among the years, this figure has tree axes: (y1) quantity of incident reports; (x) year; and (y2) quantity of Safety Alerts. All this information about "Fatalities".

In this figure every information presented in color blue is related to incident reports and information presented in orange is related with Safety Alerts.

Figure 3.14 displays information of incident reports and Safety Alerts vs. year. All black circles represent non effective Safety Alerts. They were considered non effective because as black arrows point the quantity of incident reports increased in the following years. On the other hand, red circles point out effective Safety Alerts, observe that red arrows denote the decrease of incident reports in following years.

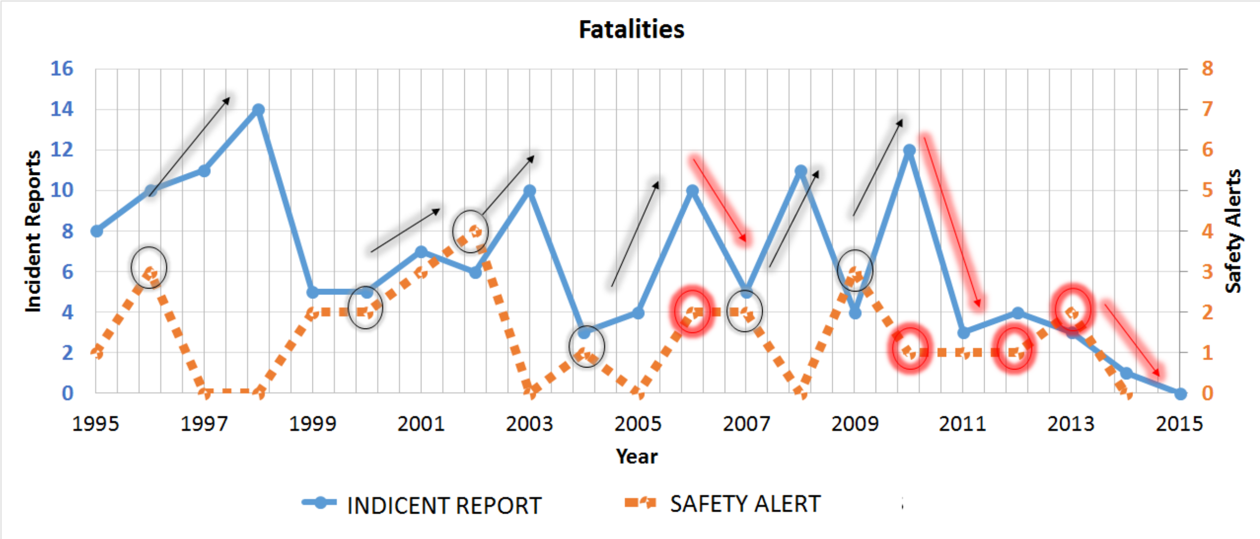


Figure 3.14 Effectiveness of Safety Alerts to avoid fatalities.

Other results obtained for this scenario are presented in Section 1.

Scenario 2: This scenario contemplates experienced people that develop specific tasks as those that are part of the operational staff in offshore platforms. These kind of end user needs specific information according to the operations they execute.

Therefore, the structure denominated "explicit relationship" of document-ontology has been structured. This structure is similar to tree-maps. This structure has been developed classifying the information by operation and therefore relating it to the operational ontology developed by Miura (2004). This structure is represented in Figure 3.15

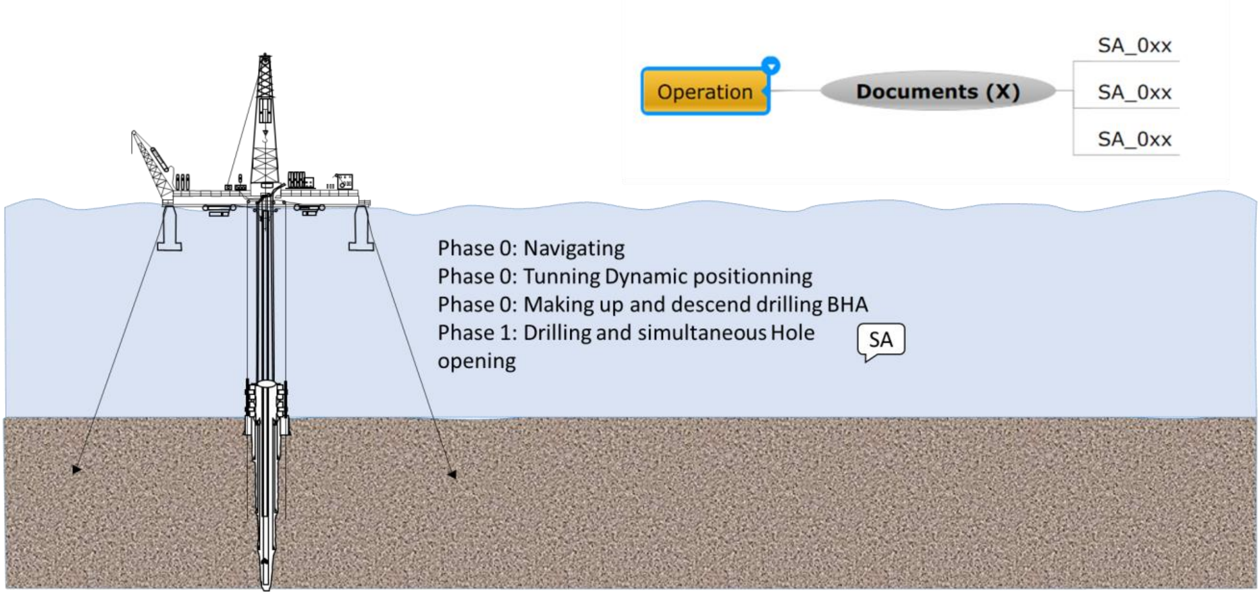


Figure 3.15 Representation of explicit relationship used to determine relevant Safety Alerts by operation.

As Figure 3.15 illustrates, this explicit relationship of safety alert-ontology of operations could be used by the well construction staff during the development of different operations.

This kind of structure has been obtained for different operations (presented in Section 4.1 of Chapter 4) that may be useful and helpful before each operation to learn about the risks, during the development of each operation to find valuable information from the content as fast as possible, and after each operation to look for similar incidents, and report it according to existing information.

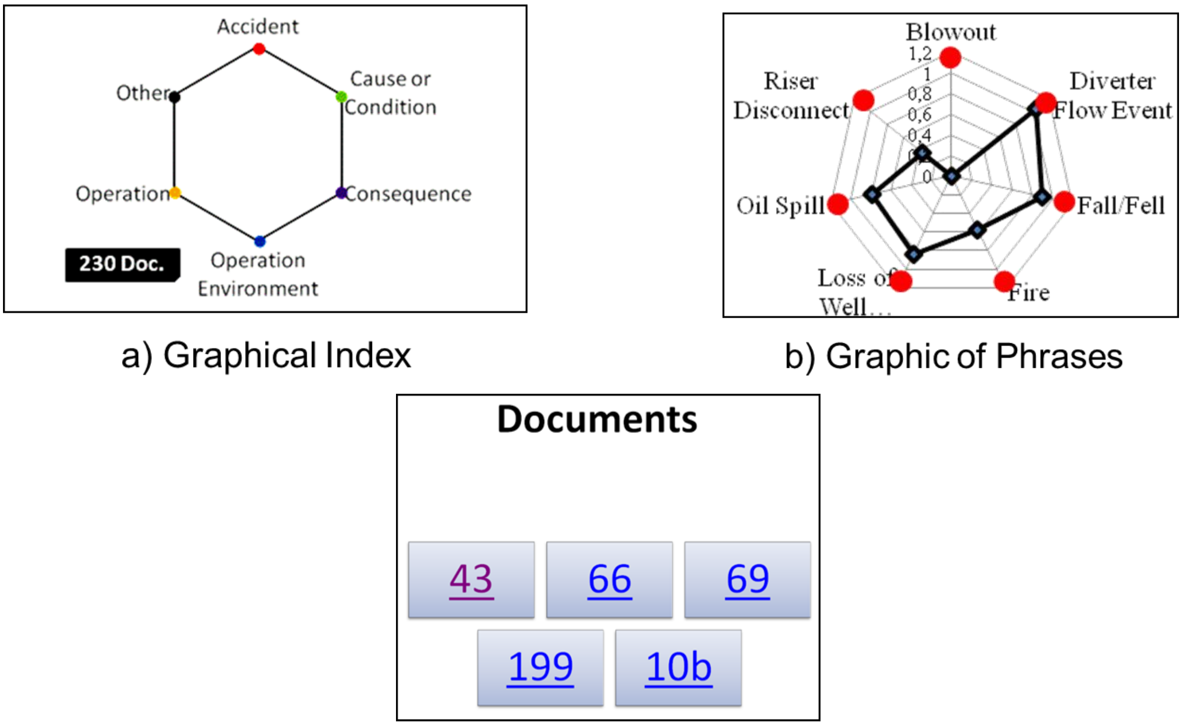
Scenario 3: This scenario was intended to meet the requirements of technical staff beginners (end users), people with little or no experience that should learn many new things. In this case tuition of an experienced person is very important because beginners do not know which information is relevant to learn, so they will try to read, understand and remember everything, but as explained in Chapter 1 it is improbable. Moreover, the chances to remember relevant information when needed decreases due to the large amount of information studied.

Therefore, the time invested in trying to learn everything could be considered as waste of time and waste of time always imply loss of money, but those aren't the only aspects that matters because safety of people is also important.

The structure developed for this scenario is a "Multilayer Knowledge Graph". Such structure has been developed by the author, It is a type of knowledge graph composed by various layers that could be divided on three different models. Those layers, by their characteristics and function, were titled as "Graphical Index", "Graphical Content" and "Related Documents", the layer "Graphical content" was built by using radar data charts. The models of those layers are displayed in Figure 3.16.

Each chart and layer was built and related according to the relationships identified in the relating concepts process.

Note that "chart" is the type of graph generated for each group of information, and the "knowledge graph" is the set of charts interrelated representing the knowledge found in the database.



a) Graphical Index

b) Graphic of Phrases

c) Related Documents

Figure 3.16 Representation of the layers of the “Multilayer Knowledge Graph”.

The model “radar” (see Figure 2.13) was preferred due to the possibility it offers to compare the relevance between the semantic phrases and display the relationship between them. The structure should assist to the beginners or people with poor knowledge to find relevant knowledge about any issue. In such manner, this structure takes the role of the experienced person about tuition tasks, because it displays the 20% of the most relevant concepts and their interrelationships.

More details about this structure could be found in Chapter 4, in addition to an example of use.

In this chapter described the processes of the proposed methodology that allows to acquire relevant knowledge, filter databases, find information about specific issues, and build structures according to the user concerns. The results obtained from the methodology are described in the following chapter.

4. RESULTS

The chapter presents argumentations about potential benefits offered by results obtained from BSEE’s and UNICAMP’s database.

Section 4.1 discusses about the models of structured knowledge built to different users with the content of BSEE’s database.

Section 4.2 presents the test performed using CEP-UNICAMP database. It evidences the effectiveness of “relevance” definition presented in Section 2.2.

Section 4.3 presents the second test that proves the effectiveness of the methodology in front of conventional search methods.

Finally, the Section 4.4 describes the advantages that the methodology presents in comparison to conventional search methods.

4.1. Structuring BSEE’s relevant knowledge to improve its dissemination

Three different types of structured knowledge models obtained and introduced in Section 3.3 from Chapter 3 are described in this section. The structured models are Data charts, explicit relationship (document-ontology), and Multilayer Knowledge Graph, each of them are described below.

- **Data Charts**

The results obtained by applying the concept of relevance presented in Section 2.2. Were used for this application to find Safety Alerts that were more effective over the years, those that allowed to reduce the occurrence of undesirable events and contain relevant information to be disseminated.

This result was obtained for Scenario 1 described on Section 3.3 of Chapter 3 in order to show that the methodology could be a powerful tool for data analysts. The first data chart obtained has been shown in Figure 3.14, this chart besides being the first chart obtained, is the model of how should be interpreted the other charts to be presented here.

To build this charts, Safety Alerts were classified by year and content as documents containing information of fatalities, injuries, loss of well control, spills ≥ 50bbls and fire/ explosions. This information has been plotted and compared with the information of incident reports separated in the same categories (fatalities, injuries, loss of well control, etc.).

Therefore Figure 4.1 to Figure 4.4 are the plots that will allow us to analyze the effectiveness that Safety Alerts had over the years to avoid the recurrence of injuries, well control, spills of more than 50bbls and fire and explosions.

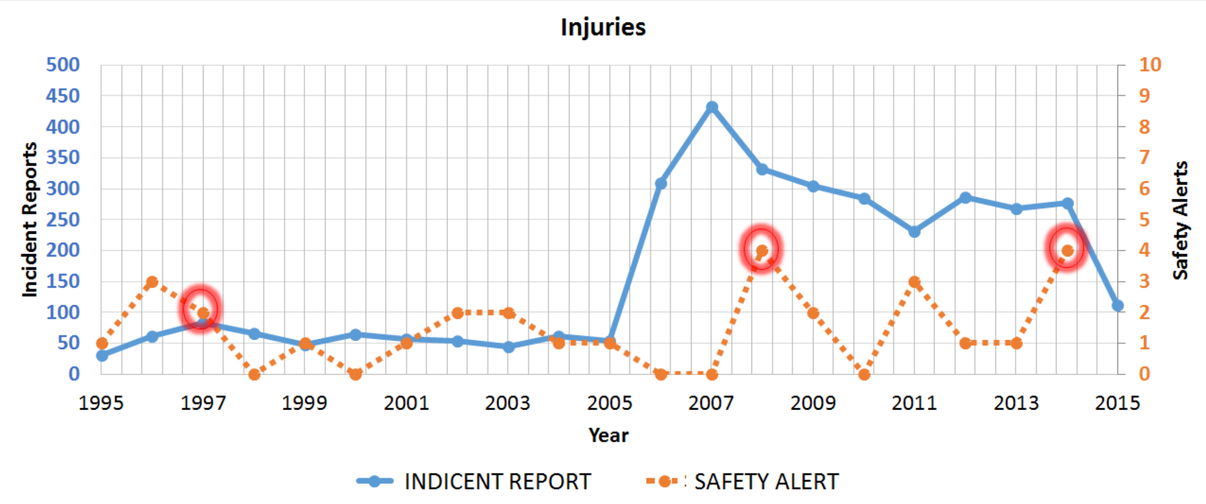


Figure 4.1 Effectiveness of Safety Alerts to avoid Injuries.

Figure 4.1 correlates information of incident reports and Safety Alerts of injuries by year. According to these graphs, Safety Alerts that contain relevant information were published in 1997 (2 SA), 2008 (4 SA) and in 2014 (4 SA).

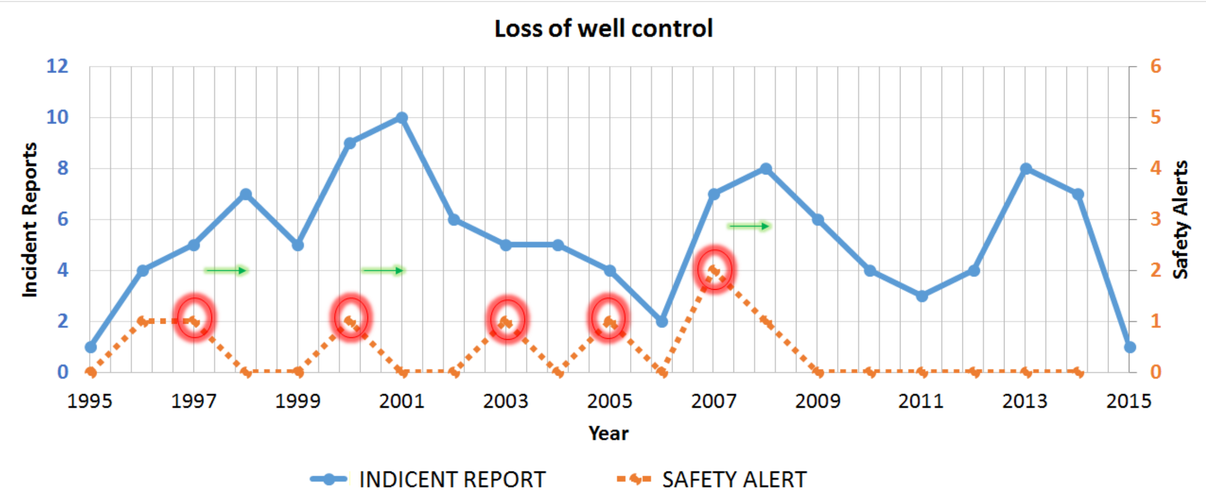


Figure 4.2 Effectiveness of Safety Alerts to avoid loss of well control.

In Figure 4.2 is possible to observe that the dissemination of knowledge contained in Safety Alerts about loss of well control published in 1997, 2000 and 2007 had a delay of one year. The interpretation of the graph is because after the Safety Alerts were published, the incident reports continued increasing for one more year, and after that year they decreased without the necessity to publish another safety alert.

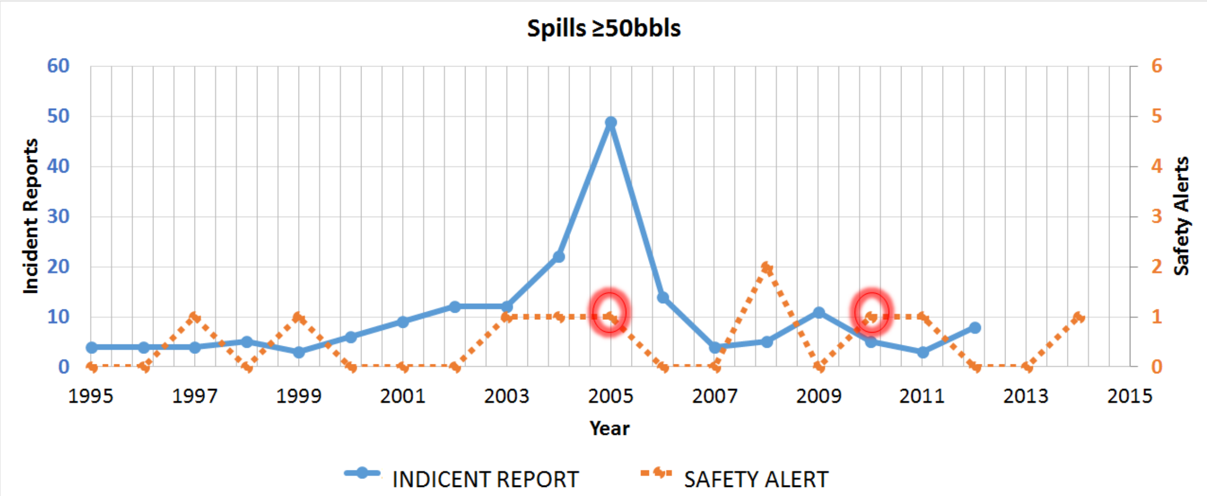


Figure 4.3 Effectiveness of Safety Alerts to avoid Spills ≥ 50bbls.

According to the Figure 4.3 is possible to interpret that the safety alert published in 2005 was the most effective one and that only 2 Safety Alerts helped effectively to avoid the recurrence of spills since 1995.

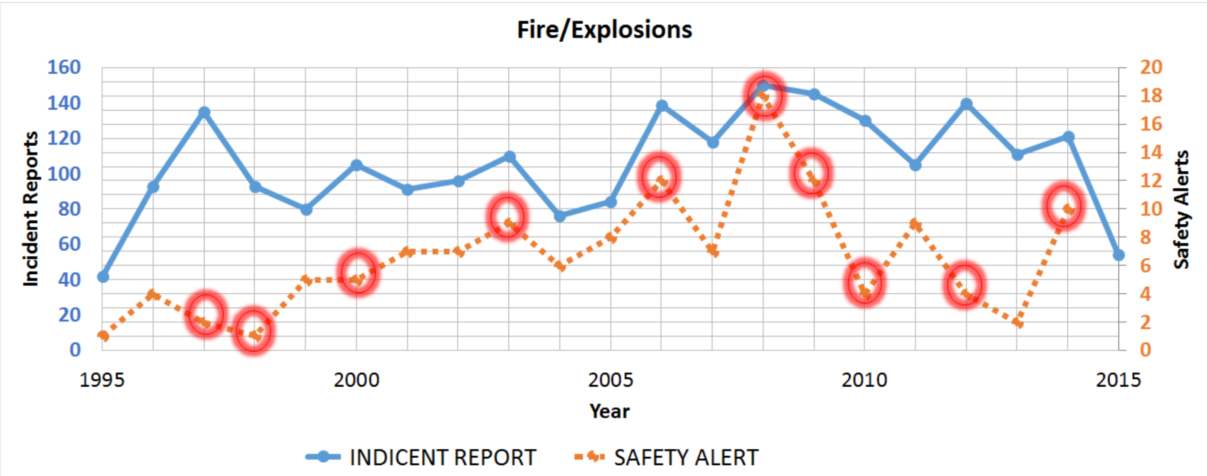


Figure 4.4 Effectiveness of Safety Alerts to avoid Fire/Explosions.

Figure 4.4 presents really interesting information. It displays more quantity of Safety Alerts that were effective, but it also presents a higher quantity of reported incidents. Moreover it was observed in this graph in the years 2003 - 2010, that the quantity of published Safety Alerts has a high correlation with the incidents reported.

The figures presented above are part of one example of use and they are the results obtained by the methodology. The following section presents another structure, useful for other kind of users, operational staff of offshore platforms.

- **Explicit relationship (document-ontology)**

Ontologies are important tools used to improve the dissemination of knowledge, by relating various ontologies is possible to enhance their ability to disseminate knowledge. The results obtained from Safety Alerts so they can be related with the ontology of operations presented by Miura (2004). This structure has been built in order to find relevant information for users of Scenario 2 presented in Section 3.3

Figure 4.5 Safety Alerts classified by cementing operation that is presented in Miura's ontology (2004). It present 20 Safety Alerts relative to cementing operations accidents or incidents, five about blowouts, seven about diverter flow events, four about oil spills, three about loss of well control and one about fall or fell.

Others explicit relationships classified by operation are presented in Appendix A.

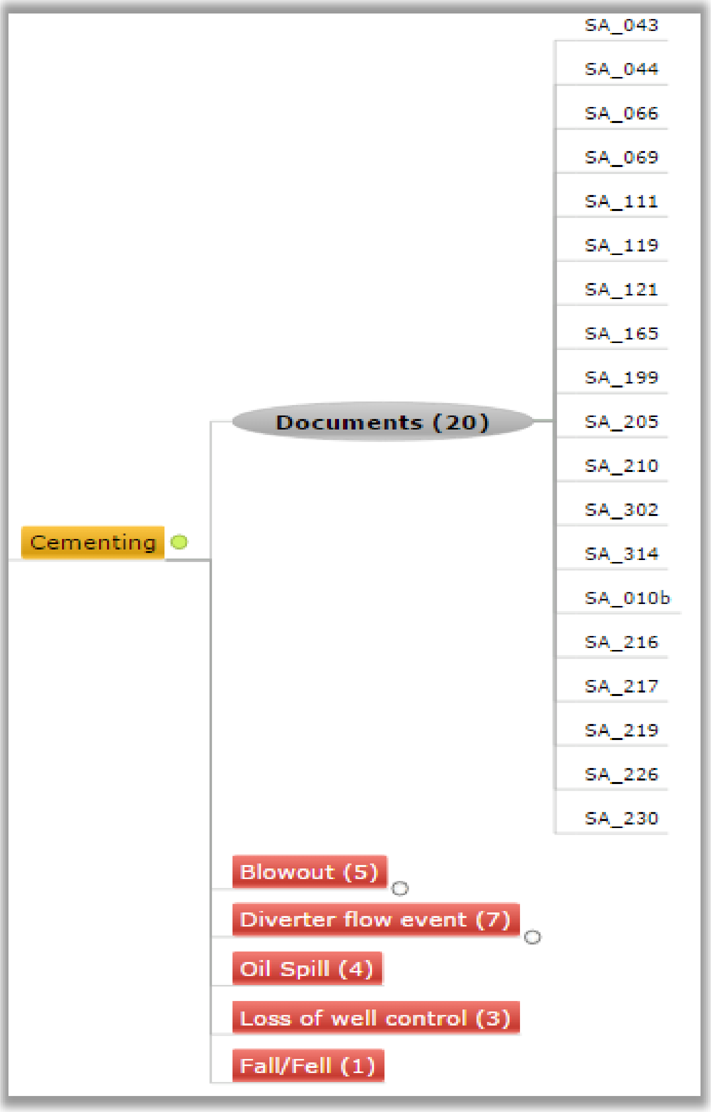


Figure 4.5 Sample of Safety Alerts concerning to cementing operations.

- **Multilayer Knowledge Graph**

The Multilayer Knowledge Graph is a proposal of the author where the 20% of the most relevant concepts and their interrelationship are displayed. This structure has been built to meet the necessities of users of Scenario 3 presented in Section 3.3.

The proposed knowledge graph consists on multiple hyperlinked layers that due to their characteristics and functionality were classified as: “Graphical Index”, “Graphic of Phrases”, and “Related Documents”.

Characteristics of those layers are revealed in Figure 4.6, Figure 4.7 and Figure 4.8 followed by a brief description.

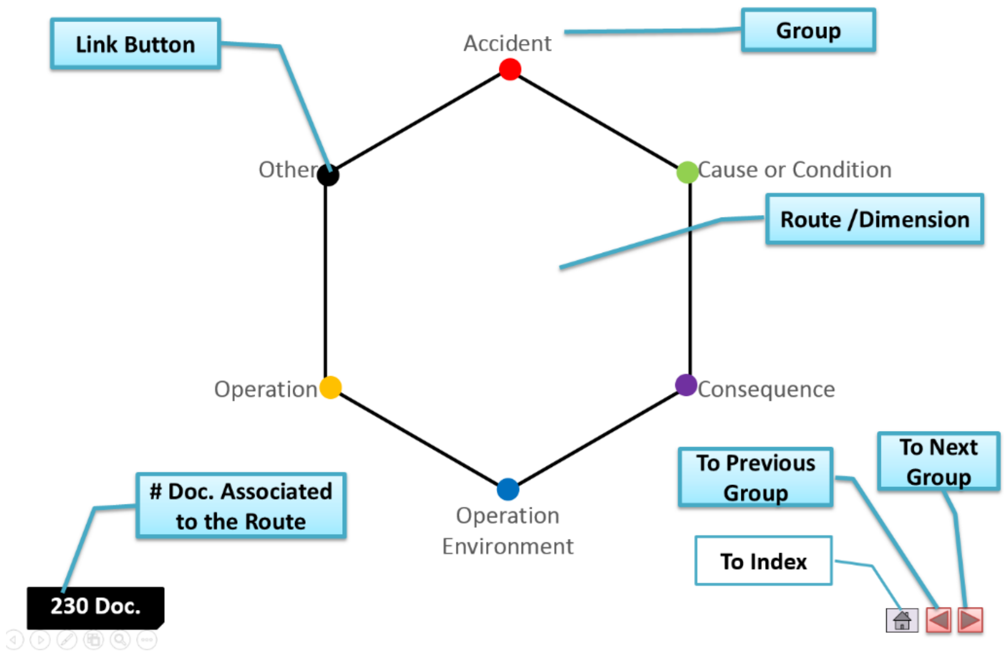


Figure 4.6 “Graphical Index” model.

The “Graphical Index” model (Figure 4.6) is composed by: **Groups**, defined by the user to group similar concepts according to Table 3.2, **Link Buttons** that enable the navigation through the knowledge graph directing to “Graphic of Phrases” or to “Related Documents”, **Route or Dimension** that display relevant phrases, selected by the user while searching for specific information and **Number of Documents Associated to the Route** that reveals the quantity of documents associated with the information selected by the user while performing the search. This is useful to filter documents containing specific information.

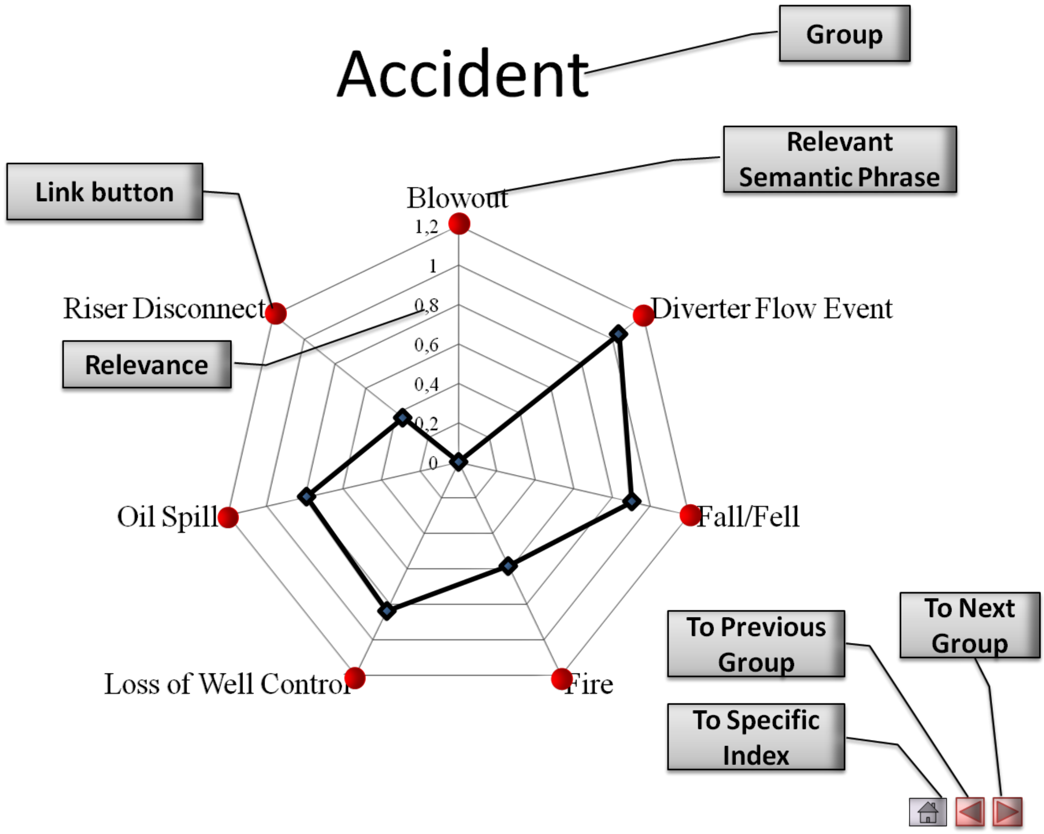


Figure 4.7 “Graphic of Phrases” model.

The Figure 4.7 present the “Graphic of Phrases” model proposed and their characteristics.

This example contains the **Relevant Semantic Phrases** of the **Group** of accidents and the **Relevance** of each semantic phrase is presented on a radial scale. Finally, **Link Buttons** that allows to the user navigating through the knowledge graph.

The “Related Documents” layer model presented in Figure 4.8, is destined to show the total quantity of documents related to the semantic phrases selected by the user in the searching process. This layer consists on **Linked buttons** identified by the number of the referent Safety Alert. Those buttons are linked with documents containing the information selected by the user, it is the **Route**.

By clicking on any linked numbered button, the **Safety Alert** concerning to that number is retrieved and revealed to the user.

Link assistant buttons allows to the user navigate on the knowledge graph.

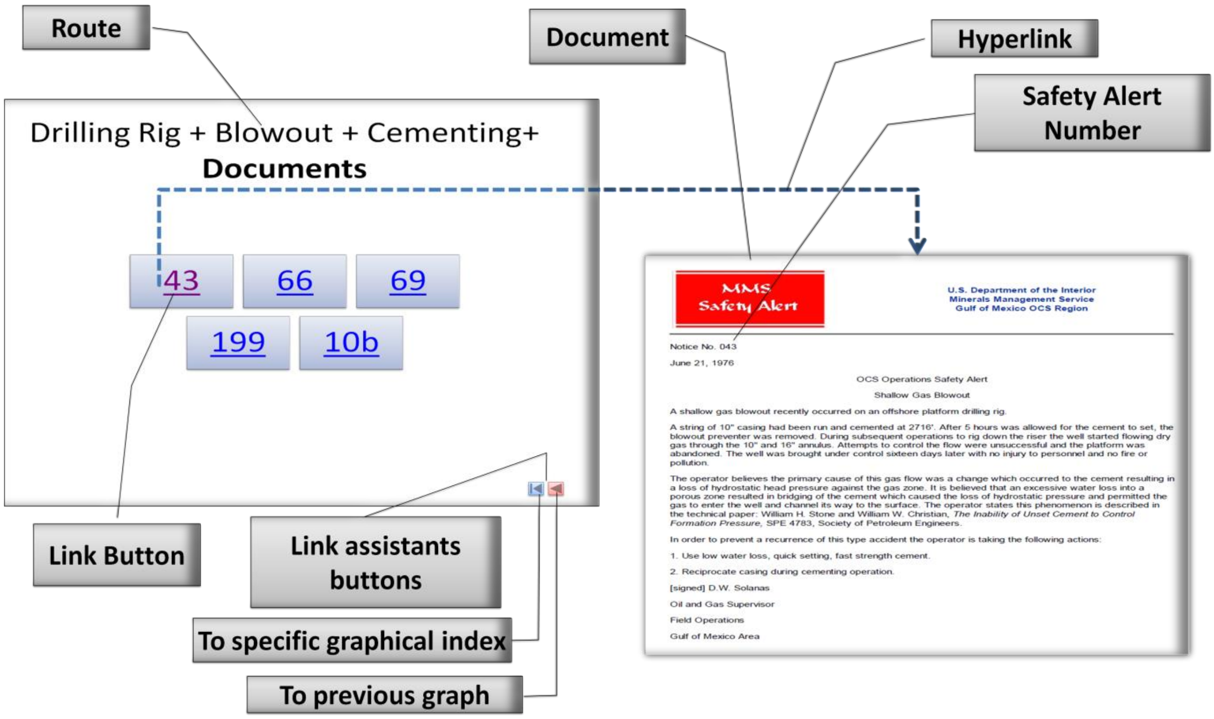


Figure 4.8 “Related Documents” model.

This Multilayer Knowledge Graph allows manipulating and comprehending the database content in addition to the possibility of retrieving documents.

The results presented in this section proved new knowledge could be obtained from one database by using different variables and structures. The results here presented can bring a great advantage for the industry if correctly used for the different users according to their concerns.

Other models of structures can be built, it only depends on the information required by the user or the analysis that the user wants to perform.

An example about how to perform a search in the Multilayer Knowledge Graph is presented in Figure 4.9. It starts in the “Graphical Index” with 230 documents. The objective of the example is:

- To find the most relevant operation related with blowouts, occurred in drilling rigs, and documents containing such information.

To achieve the objective, the user performs the following actions:

The user chooses the group “Operation Environment”, see Figure 4.9 (A), with this action a new layer of “Graphic of phrases” (B) is opened containing three concepts (Drilling Rig, Well, and Platform Workover) that were classified as operation environment according to Table 3.1. From those concepts, Drilling Rig has been selected by the user, and a new

“Graphical Index” (C) was opened, it relating Drilling rig (the concept selected by the user) with every group. From this layer, the group accident has been chosen, so the next layer (D) that displays the accidents that are related with Drilling Rig, was opened, from this layer containing seven relevant concepts, the less relevant but established by the example (Blowout) has been chosen, whit this action the layer (E) has been displayed, it relating Drilling Rig, Blowout and the groups. Finally, the group “Operation” was chosen and the layer (F) opened, from which is possible to observe that from 20 operations, “Cementing” is the most relevant.

Until here, the first part of the example’s objective (to found the most relevant operation related with blowouts occurred in drilling rig) has been accomplished. The most relevant operation, related with blowout and drilling rig is cementing.

Now to accomplish the second part of the example, (to found the documents containing the information searched) the user selected from (F) the concept “cementing”, in order to open the “Graphical Index” that relates Drilling Rig, Blowout and Cementing to the other groups. In the lower left of (G), is possible to observe the button that displays the information of the quantity of documents, related to the route followed by the user, exists in the database. (For more information about the “Graphical Index” see Figure 4.6)

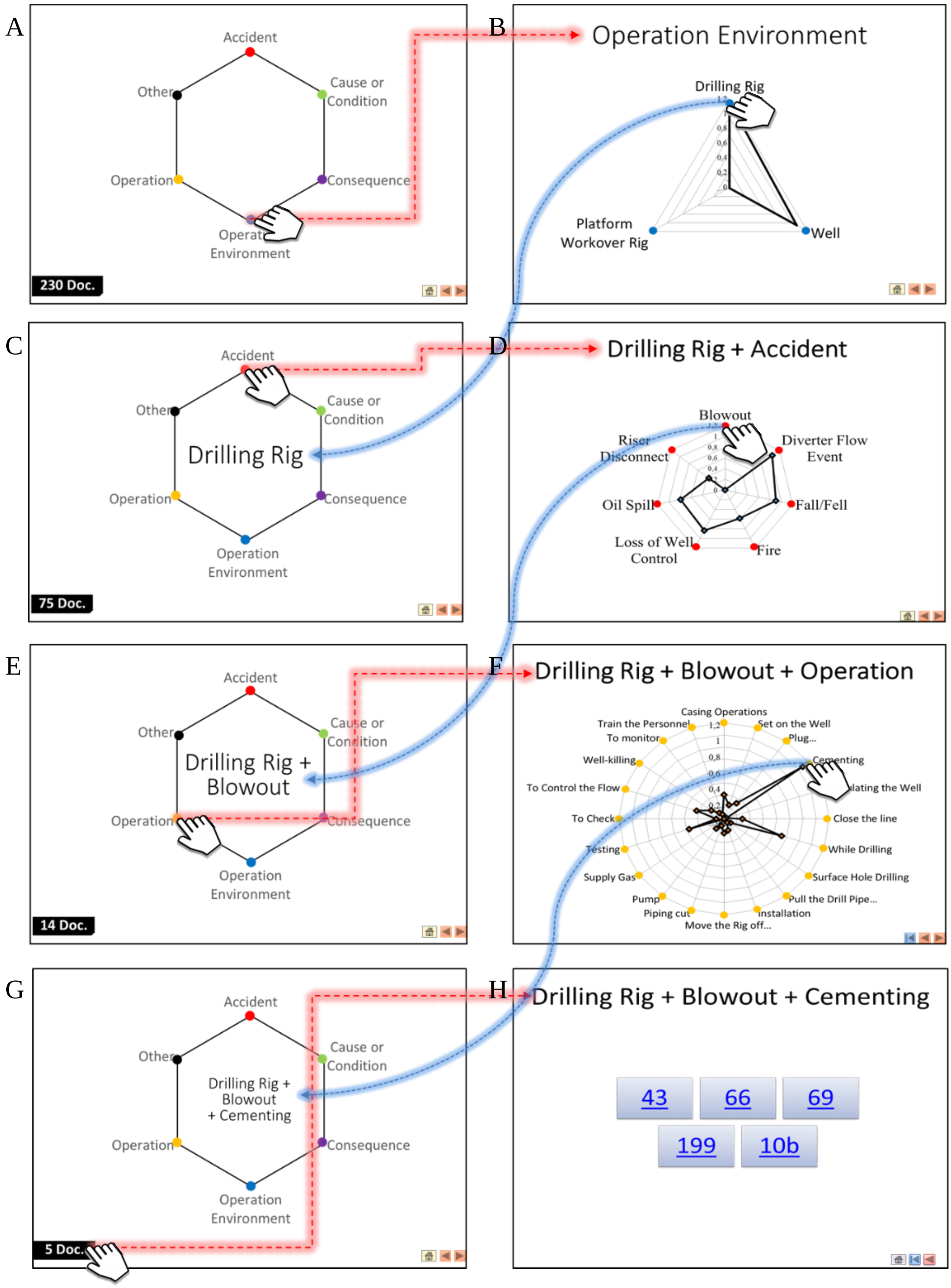


Figure 4.9 Example of search for content in structured knowledge.

Note: Observe that in layers (A), (C), (E) and (G) the quantity of documents decreases from two hundred and thirty (230) to five (5); five is a reasonable quantity of documents that a person can read, understand and remember according to Miller (1967).

From Figure 4.10 is possible to observe that the methodology permits to filter the database until a reasonable quantity of documents desired by the user according to the requirements of content.

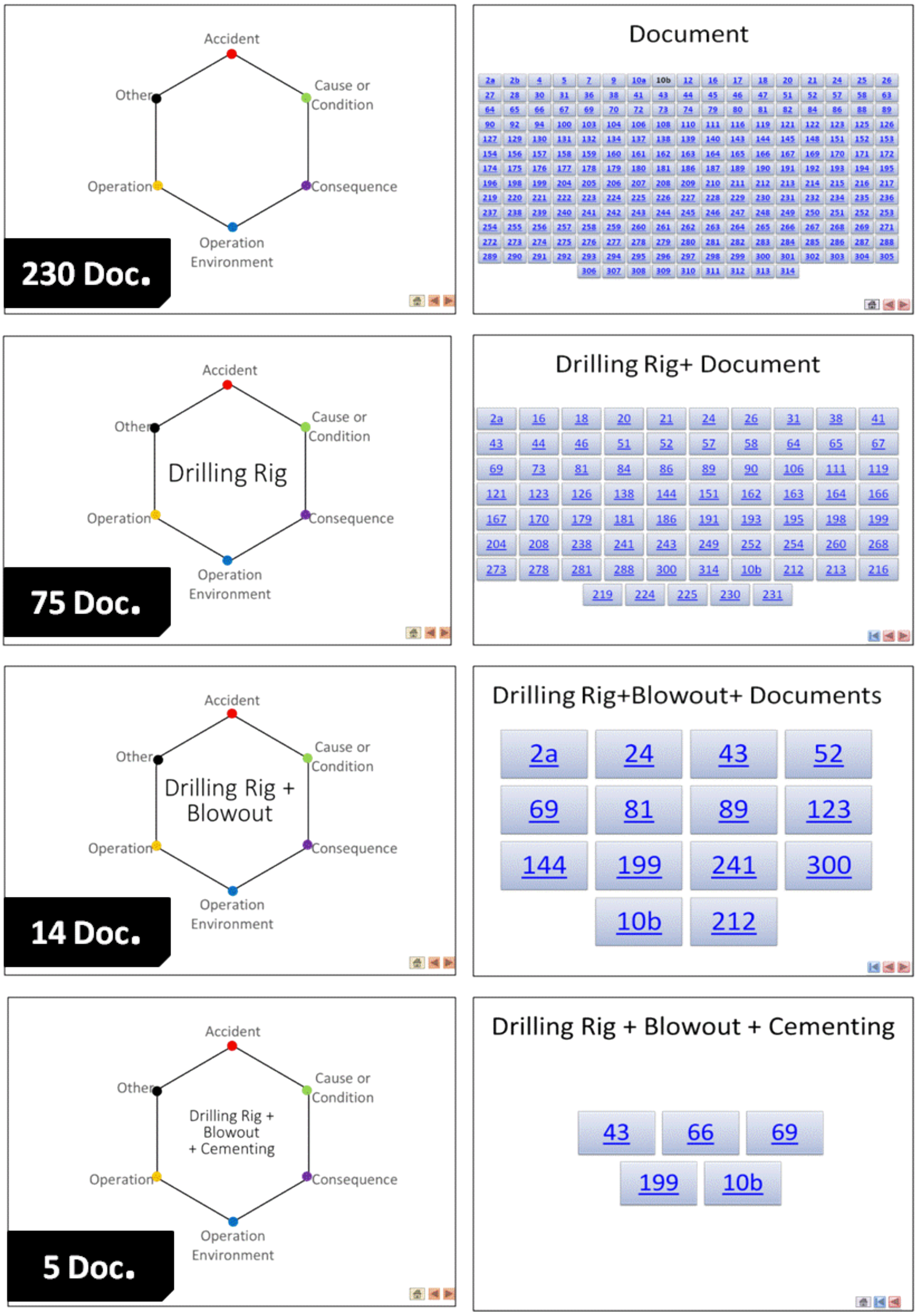


Figure 4.10 Quantity of Documents related to different dimensions: General Well Construction (230 Associated Documents); Drilling Rig (75 Associated Documents); Drilling Rig and Blowout (14 Associated Documents); Drilling Rig, Blowout, Cementing (5 Associated Documents).

Returning to the example, from layer (G) the user clicks on the “5 Doc.” button, and the layer H that is “Related Documents” model was opened, this layer contains five hyperlinked buttons which opens the Safety Alert related to the number of the button.

These kind of structured knowledge (Multilayer Knowledge Graph) could be built for other applications but note that the groups and relevance of concepts will vary according to the database content.

The advantage of this structure is that can reveal the 20% most relevant content of any database, so the user do not need previous knowledge about the content to found interesting information about any issue contained in the database. An important advantage will be further discussed in the following section.

4.2. Search for relevant content in UNICAMP`s database

Identify “relevant knowledge” is the first step to accomplish the main objective of this dissertation. The definition of relevance is presented in Section 2.2 This definition allowed finding significant information according to user’s concerns.

To prove that search by “relevant content” effectively improves the search by conventional approach (as used by librarians), a test has been performed. The test consisted in find out relevant master theses and doctoral dissertations to four graduate students of the petroleum science and engineering program. For this, each student has been asked about key concepts (As defined in Section 3.2 of Chapter 3) of their actual researches. These key concepts are presented in Table 4.1.

Table 4.1 Key concepts furnished by students.

Graduate Students	Key Concepts
Master Student W	ESP – Electrical submersible pumping, BCS Bombeio centrífugo submerso, droplet size distribution, distribuição de tamanho de gotas, emulsion flow, escoamento de emulsão, light back scattering, retroespalhamento de luz, image processing, processamento de imagem.
Master Student X	Re-start of gelled lines, repartida ou reinicio de linhas gelificadas, wax deposition, deposição de parafinas, thixotropic fluids, fluidos tixotrópicos, viscoelastic behavior, comportamento viscoelástico, waxy crude oil, óleo parafínicos, reology, reologia, paraffin crystals, cristais de parafina, flow assurance, garantia de escoamento.
Master Student Y	Disspertion coefficient, coeficiente de dispersão, concentration in-situ, concentração in-situ, CTRW-Continous Time Random Walk, Tomografia computorizada de Raios-X, Número de Peclet, Modelos de prospecção, Coquina, Rocha carbonática, Injeção de CO_2.
Master Student Z	Optimization WAG CO_2, Optimization of the water alternating gas injection process. Optimização do processo de injeção alternada água-gás.

Note that in Table 4.2 key concepts are in written in English and in Portuguese, this is because in UNICAMP's database thesis and dissertations could be found in both languages.

By applying the methodology in UNICAMP's database using the key concepts provided by the students were found documents that could be interesting to each student. These documents were presented to the students and they classified them as: (A) known documents; (B) new (previously unknown) and interesting documents; and (C) documents that has no relationship to their researches (see Table 4.2).

Table 4.2. Comparison between documents found by the methodology and conventional search methods.

Student	Quantity of documents found by the methodology					
	Total (T)	Found by conventional search methods (A)	Interesting, that were not found by conventional search methods (B)	Increment of revealed sources of knowledge. (Sk%)	Noisy information, non-related documents (C)	Error (E%)
Master Student W	28	5	8	160%	15	53,57%
Master Student X	8	2	5	250%	1	12,5%
Master Student Y	34	1	16	1600%	17	50%
Master Student Z	7	1	1	100%	5	71,43%

By analyzing the Table 4.2, is possible to observe that a higher quantity of documents interesting to the students were discovered by the methodology than with conventional search methods. In this table, the column (T) represents the total quantity of documents found by the methodology for each student according to the key concepts provided. The column (A) shows the quantity of documents from (T) that the students found before using conventional search methods; (B) indicates the quantity of interesting document from (T) that the students didn't found before, documents of (B) were not considered in this column. In column (Sk%) is represented the increment in percentage of sources of knowledge found by the methodology in contrast to those found by conventional search methods, it has been calculated with Equation 5.1.

$$(Sk\%) = \frac{(B)*100}{(A)} \qquad \text{Eq. (5.1)}$$

Also the column (C) displays the information about the quantity of non-related documents (see Eq. 5.2), those are considered as being noise, this information is useful to determine the percentage of error shown in column (E%) this error correspond to the experiment presented above, it has been calculated with the Equation 5.3.

$$(C) = (T) - (A) - (B) \qquad \text{Eq. (5.2)}$$

$$(\%E) = \frac{(C)*100}{(T)} \qquad \text{Eq. (5.3)}$$

According to the information displayed in Table 4.2 is possible to figure out that the methodology can increment the quantity of sources of knowledge in more than one hundred percent (100%). Moreover the percentage of error in most of the cases exceeded the fifty percent (50%), it is higher than expected but it can be explained by two possible circumstances:

1) Key concepts chosen by the students were not clear, probably contained too much noisy information or probably they didn't choose the best words, it is words considered by the set of authors of the dissertations selected. To verify if it was the problem, a new test has been developed now only with the documents chosen by the students. This test aims to find the most relevant key concepts considered in the documents chosen. For this, the methodology has been applied again over each "database of interest" and a list with the most relevant concepts were obtained, this list is shown in the Table 4.3.

Table 4.3 Relevant key concepts found by the methodology.

Graduate Students	Relevant Key Concepts from "database of interest"
Master Student W	Droplet size distribution, distribuição de tamanho de gotas, gotículas light back scattering, retro-espalhamento de luz.
Master Student X	Gelificação, Parafinas, Cristais, crudo pesado, Garantia de escoamento.
Master Student Y	CTRW-Continous Time Random Wlak, Tomografia, Raios X, Injeção de CO_2, Recuperação melhorada.
Master Student Z	Alternate water-gas injection.

2) The information of phrases displayed by the PhDic program during the text mining process (As the one presented in Figure 3.4) was not presented to the students. This may be another contributing factor to obtain a significant error, because if that information would be presented to them, they could easily select relevant information contained in the documents according to their necessities, but this problem could be solved by representing the key

concepts found, in a Multilayer Knowledge Graph as that presented in in Section 4.1, so the students could choose the most relevant concepts and filter the documents in an interactive search similar to that presented in Figure 4.9.

The two previous sections presented the results obtained by applying the methodology in BSSE's and CEP-UNICAMP's databases. The following section presents the advantages that those results can represent to the petroleum industry, it should help to recognize the importance of acquire and disseminate not only explicit, but tacit knowledge.

4.3. Methodology Advantages

In this section are described the advantages of the proposed method. The Table 4.4 presents a comparison between the benefits that the methodology presents in front of traditional search methods.

Table 4.4 Benefits of conventional search methods vs. proposed method.

Conventional Search Methods	Proposed Method
Allows searching for title, author, keywords, date, keywords or content (connectionist methods).	Allows searching for title, author, key concepts, date or content (cognitive and connectionist methods).
Reveals only explicit knowledge.	Reveals explicit and tacit knowledge.
Reveals one person's knowledge.	Reveals relevant knowledge of and for community.
Require previous knowledge of keywords to develop the search.	Do not require previous knowledge to perform a search, because the content is visible.
Information dissemination is great, but knowledge dissemination is not efficient.	Turns easier the dissemination of knowledge.

These benefits allow us to have the following advantages:

- **No previous knowledge is required**

From the results obtained of the test in Section 4.2 and with the explanation of use of the Multilayer Knowledge Graph presented in Section 4.1 is possible to affirm that no previous knowledge is required neither to apply the proposed methodology to a new database nor to search for relevant information, because the objective of this work is enable search for relevant content and to achieve this, relevant content is displayed. Therefore, the user can see the relevant content and do not need to know it previously.

The following section describes how the methodology allows reaching different levels of information, and why this is important.

- **Allows reaching different levels of information**

This section describes, based in examples previously presented, how the methodology allows reaching different levels of information and in what way this information is important.

It was demonstrated in Section 4.1 that the methodology allows reaching different levels of information and not just in one direction but in many. However, is better to describe the results previously obtained to clarify the idea:

Database of BSEE contains information of safety of offshore O&G industry. Applying the methodology and filtering documents using keywords of the content, four databases were obtained: Safety in well construction, safety in production, safety in supply vessel and helicopters and the last one are documents that couldn't be classified on these groups.

The database of safety in well construction was analyzed again and groups of accidents, causes, consequences, operations etc. were obtained.

Finally it was possible to classify Safety Alerts by operation.

For knowledge dissemination the methodology proposes to structure the knowledge obtained according to the user's concern. One example of structure that could be helpful for well construction staff is the explicit relationship presented in Section 4.1.

The explicit relationship of document-ontology enables the detection of relevant Safety Alerts according to well construction operations. As the Figure 3.15 illustrates this explicit relationship of safety alert - ontology of operations could be used by well construction staffs during the development of different operations.

Is important to note that this methodology offers the possibility to visualize the relevance (entropy) of the content (concepts and relationship between concepts) and improves the discovery of new information and sources of knowledge.

The relationship between concepts and the relevance of those relationships were made evident in the different models of structured knowledge, but the Multilayer Knowledge Graph is the only one that allows to visualize all the relationships between the relevant concepts (20% with higher entropy) contained in the database.

Those results prove that this methodology allows reaching different levels of information and in different ways, revealing the relevance of each information.

- **Displays non obvious but relevant information**

To discuss this advantage, the results obtained from BSEE's database (explicit and tacit knowledge) are compared with the current information available on BSEE`s website (explicit knowledge). The comparison is based on the information displayed in Figure 4.11.

The figure represents graphically the significance of explicit knowledge (date, safety alert number, title, keywords) and tacit knowledge (statistics and content).

The safety alert database has been obtained on the BSEE website, the information available in this website has been presented in Item a) of the Section 2.1.

The Figure 4.11, represents the visible information furnished in the BSEE's website and the information provided by the methodology.

BSEE's website provides information of date, title, safety alert number, keywords, and statistics; the methodology provides the same information and relevant content.

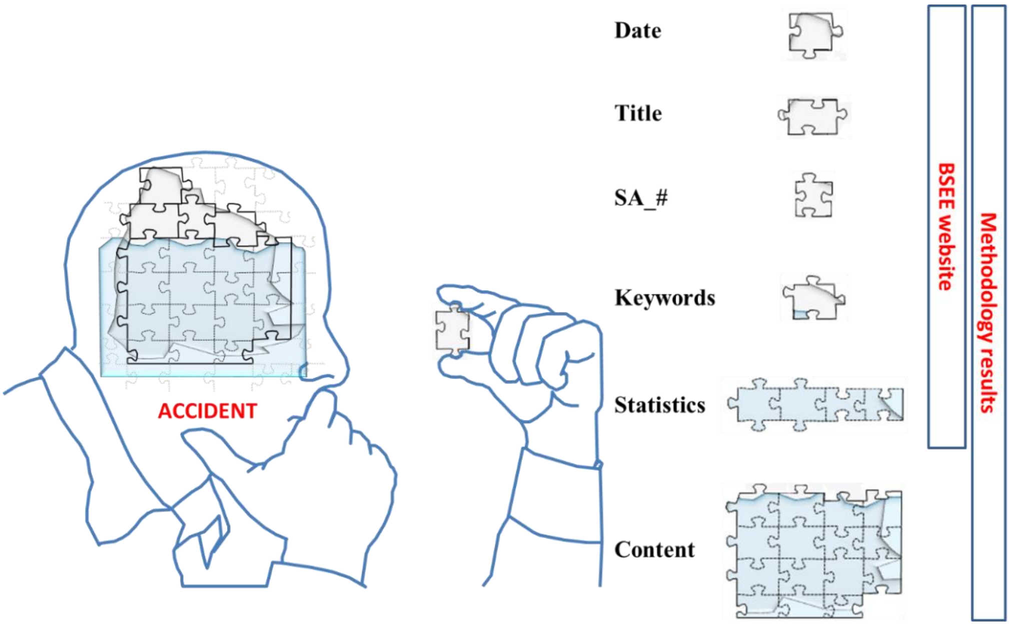


Figure 4.11 Illustration of the significance of available information on BSEE website and information found with the methodology.

Some problems found on the website that can cause misinformation and represents an obstacle to found information are:

- Exist duplicated information, about safety alert number, title and date. One example of it is shown in Table 4.5.
- Exists repeated information on the table of statistics of incident/Spill. Note in the Figure 2.4 below the table the following advertisement: "NOTE: Incidents may be counted in more than one category. For example, a fire resulting in an injury would be counted in both the fire and injury category".

Table 4.5 Sample of duplicated information found on the BSEE website.
Source: BSEE. 2015.

Date	Title
10/03/1983	Fatality While Testing Gas Turbine Meter
18/08/1983	Fire While Starting Diesel Engine with Gas-driven Engine
17/18/1983	Fire
17/18/1983	Fire
17/18/1983	Fire
15/16/1983	Fire
15/13/1983	Blowout and Fire
13/24/1983	Fire

In the Figure 4.11 the information is represented by puzzle pieces that a man analyzes in order to assemble a puzzle. The puzzle refers an iceberg in the water. The illustration's meaning o is described below:

- **Man:** represent a person or a community analyzing the available information to understand how the accident occurred and which factors contributed to the occurrence of the accident.
- **Puzzle pieces:** each puzzle piece represents different kinds of information available in BSEE's website or from the results of the methodology. Each piece is important to build the puzzle, however, not all of them belong to the same place in the puzzle. It means that they are not equally important.
- **Puzzle:** the puzzle is about an iceberg which represents an accident. This iceberg has different levels that represent the importance and the visibility of information. Date, title, Safety Alert number, keywords, statistics and content are part of the iceberg.
  - The "Title" piece is in the visible part of the iceberg it represents that the man can see this information but it doesn't reveal a clear idea of documents' content.
  - "Keywords" are represented by a puzzle piece that that is in contact with the water, this suggest that this information will provide a better idea about the accident but this is not enough to understand the entire problem.
  - "Statistics" involves more information (more than one piece), like how many times this accident occurred, which is the main cause, which are the most significant consequences, etc. This information is important

but difficult to obtain that’s why it is represented by a group of pieces of puzzle referent to the content.

- “Content” is located in the non-visible part of the iceberg. It is the knowledge contained on Safety Alerts that experts try to transmit, that information allows determining the relationship between causes consequences and other factors that contributed to the occurrence of accidents. The pieces are represented as being under the water because it is very difficult that a person could obtain all the information contained in the database and relate it manually.

As previously described content is a result of the methodology where title and keywords were considered, then regarding to the Figure 4.11 these puzzle pieces (title, keywords and content) represent the largest part of the iceberg. Therefore is possible to conclude that the methodology provides relevant information to understand the context of an accident.

- **Effectiveness of information retrieval**

For this sections, a comparison between searches developed using two different search engines (Google and BSEE`s search engine) and the proposed method were developed. The results of the searches performed with Google and BSEE search engine are presented in Appendix B and the search performed using the proposed method is equivalent to the example shown in Figure 4.9.

The Table 4.6 displays the results obtained for three cases of search:

Case #1: represents a search performed to find information about blowout in BSEE’s safety alert. The results shown by Google in its first page of result were 10, of which 2 were indeed BSEE`s Safety Alerts containing information about blowouts. The results obtained by the BSEE`s search engine were 20 from which 19 were truly Safety Alerts talking about blowouts, but applying the method 21 documents were found.

Case #2: represents a search performed to find BSEE’s Safety Alerts about blowouts occurred in drilling rigs from BSEE`s database. The results obtained by Google this time were 13, of which 5 were indeed BSEE`s Safety Alerts about blowouts in drilling rigs. The results obtained by the BSEE`s search engine were 3 from which only 1was truly safety alert talking about blowout in drilling rig, but applying the method 14 documents were found.

Case #3: represents the search performed to find Safety Alerts about blowout occurred in drilling rigs related with cementing operations. 10 results were obtained from Google of which 3 were BSEE`s Safety Alerts. With BSEE`s search engine no document was found, but applying the method 5 documents were found.

Table 4.6 Comparison of results obtained in three cases on research by using Google, BSEE`s search engine and the Proposed Method.

Keywords for Search	Google	BSEE	Proposed Method
Case #1: BSEE Safety Alert, Blowout.	2 (10)	19 (20)	21
Case #2: BSEE Safety Alert, Blowout, Drilling Rig.	5 (13)	1 (3)	14
Case #3: BSEE Safety Alert, Blowout, Drilling Rig, Cementing.	3 (10)	0 (0)	5

Results clearly show that the proposed method is more effective than traditional search methods to find information in local and specialized databases. The following section presents a comparison about different applications proving that the methodology could be applied in any local and specialized database.

- **Applicable in local and specialized databases**

The methodology to extract knowledge from textual databases has been applied before for other purposes, in Miura (1992), Guilherme (1996) and Rabelo (2008).

The characteristics of four databases analyzed with the methodology are presented in Table 4.7. The differences confirm that the methodology could be applied in any other database if it is local and specialized. Those databases are the two databases employed in this dissertation, and two others used in Miura (1992) and Miura (2004).

Table 4.7 Characteristics of four databases in which the methodology has been applied.

	Safety Alerts	**Academic Researches**	**Daily bulletin of assessment and completion (Miura, 2004)**	**Noncompliance reports (Miura, 1992)**
Language	English	Portuguese	Portuguese	Portuguese
Content	-Past incidents or accidents. -Causes, consequences and factors that contributed to the accident or incident. -Recommendations to prevent future occurrences.	-Researches in Exploitation -Researches in Reservoir and management.	Operational Procedures of well construction.	Experiences of members in a specialized area.
Region	USA – OCS (GOM, PAC, Alaska)	Brazil	Brazil	Brazil
Community of interests	People working in the offshore O&G industry.	Students, researchers, petroleum engineers.	Well construction engineers.	Well construction staff.
Results obtained	Multilayer Knowledge Graph of safety in well construction, list of relevant Safety Alerts classified by operation.	Specialized databases according to students concerns.	Ontology of construction and repair of Offshore wells.	Knowledge graphs for troubleshooting. (manually obtained)

In this chapter were presented possible applications of the results obtained by applying the methodology in BSEE’s and CEP-UNICAMP’s databases. Two tests performed to determine the effectiveness of the methodology were presented and its advantages were pointed out. The following chapter presents the conclusions obtained in this work.

5. CONCLUSIONS

The methodology presented allows acquiring explicit and tacit knowledge from local and specialized databases and proves that display tacit knowledge represents a great advantage in front to conventional search methods (see Section 4.3).

The main objective of work has been achieved by structuring knowledge obtained from text mining process in models that improves its dissemination (see Section 4.1).

Main advantages (see Section 4.3) of the methodology are: no previous knowledge is required, allows reaching different levels of information, the concept of relevance presented allows emphasizing non obvious but significant information that is relevant for a community and not only for a person.

Models of structured knowledge obtained from BSEE’s database could be used as a basis to train technical staff beginners and in risk assessment of offshore well engineering operations (see Section 3.3).

The methodology can be applied in CEP-UNICAMP to find sources of relevant information for different lines of research (see Section 4.2).

A future work that can be performed to evaluate the effectiveness of methodology in front of human capacity to parsing big databases is: apply the methodology in BSEE’s incident reports and compare the results with those obtained in Oliveira 2004.

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APPENDIX

APPENDIX A – EXPLICIT RELATIONSHIP EXAMPLES

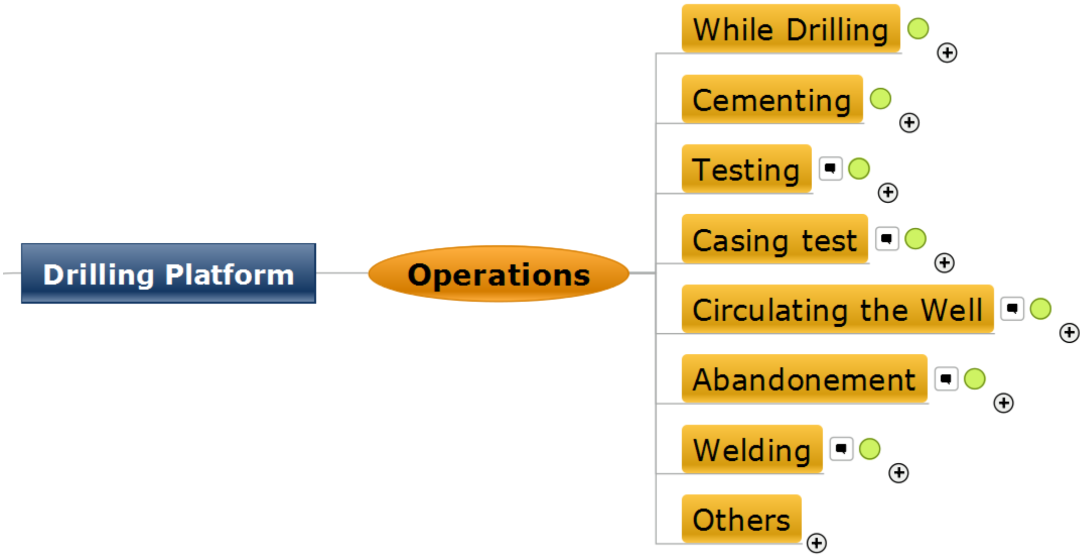

Figure A.1 Operations that produced relevant accidents in Drilling Platforms.

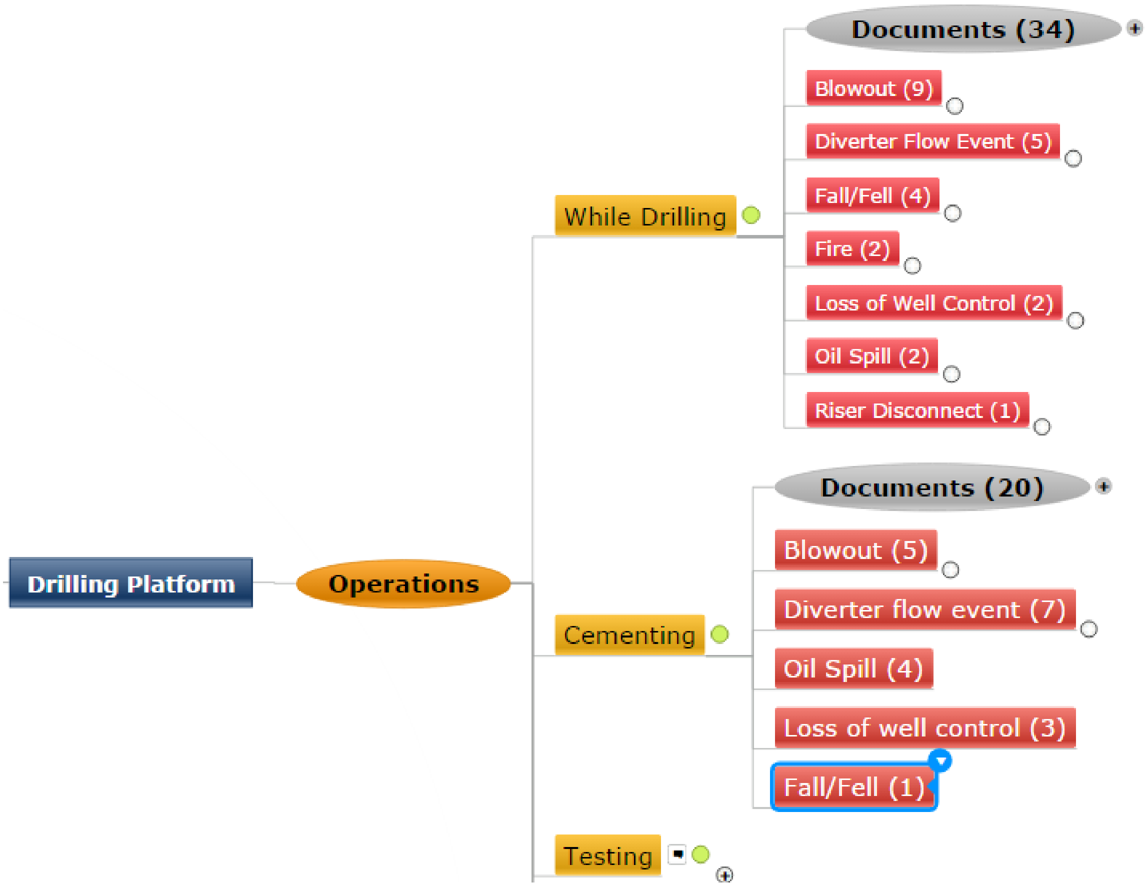

Figure A.2 Accidents that occurred while drilling, and in cementing operations. The number in parenthesis represent the quantity of related Safety Alerts.

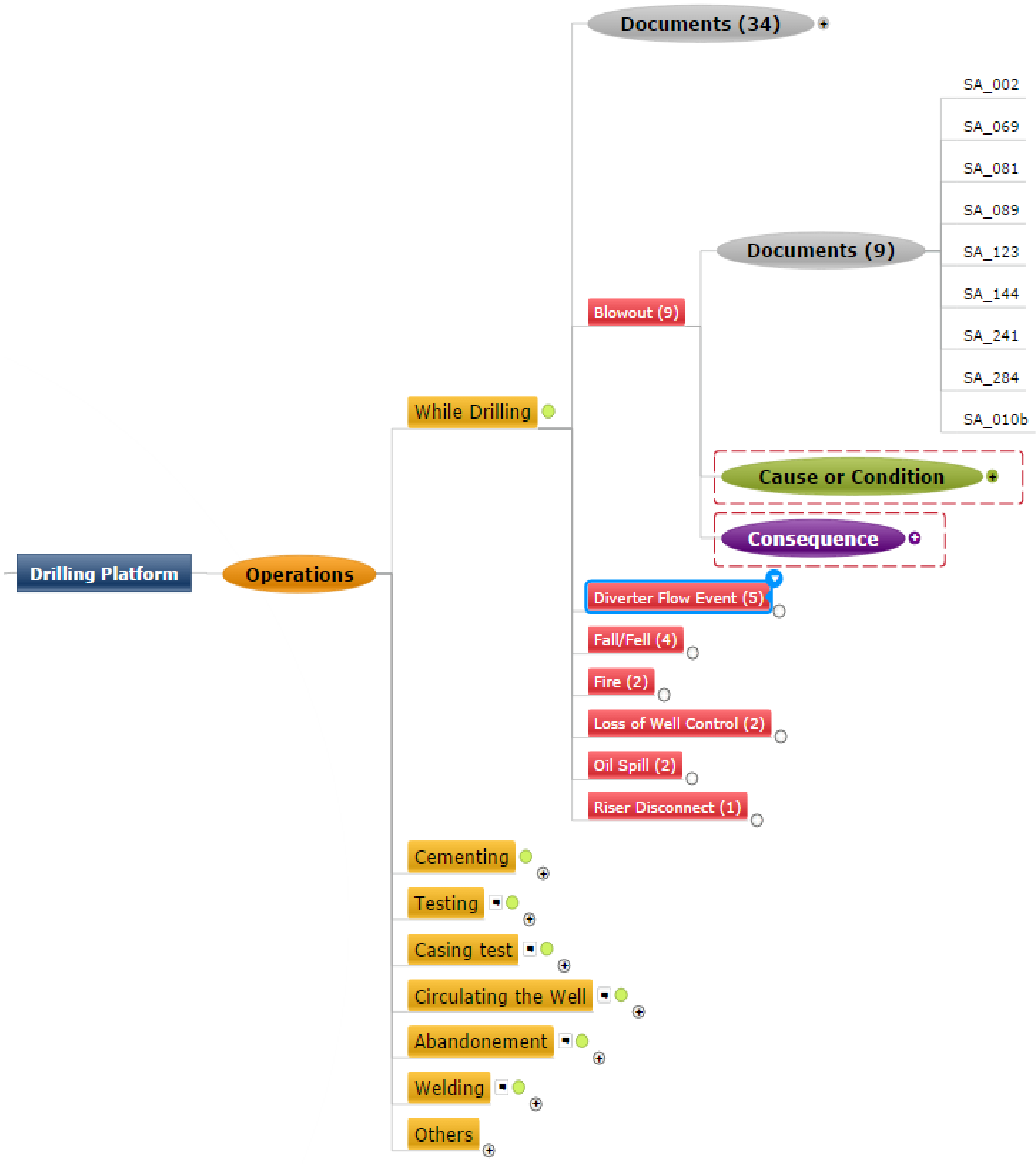

Figure A.3 Safety Alerts related to Blowouts while drilling.

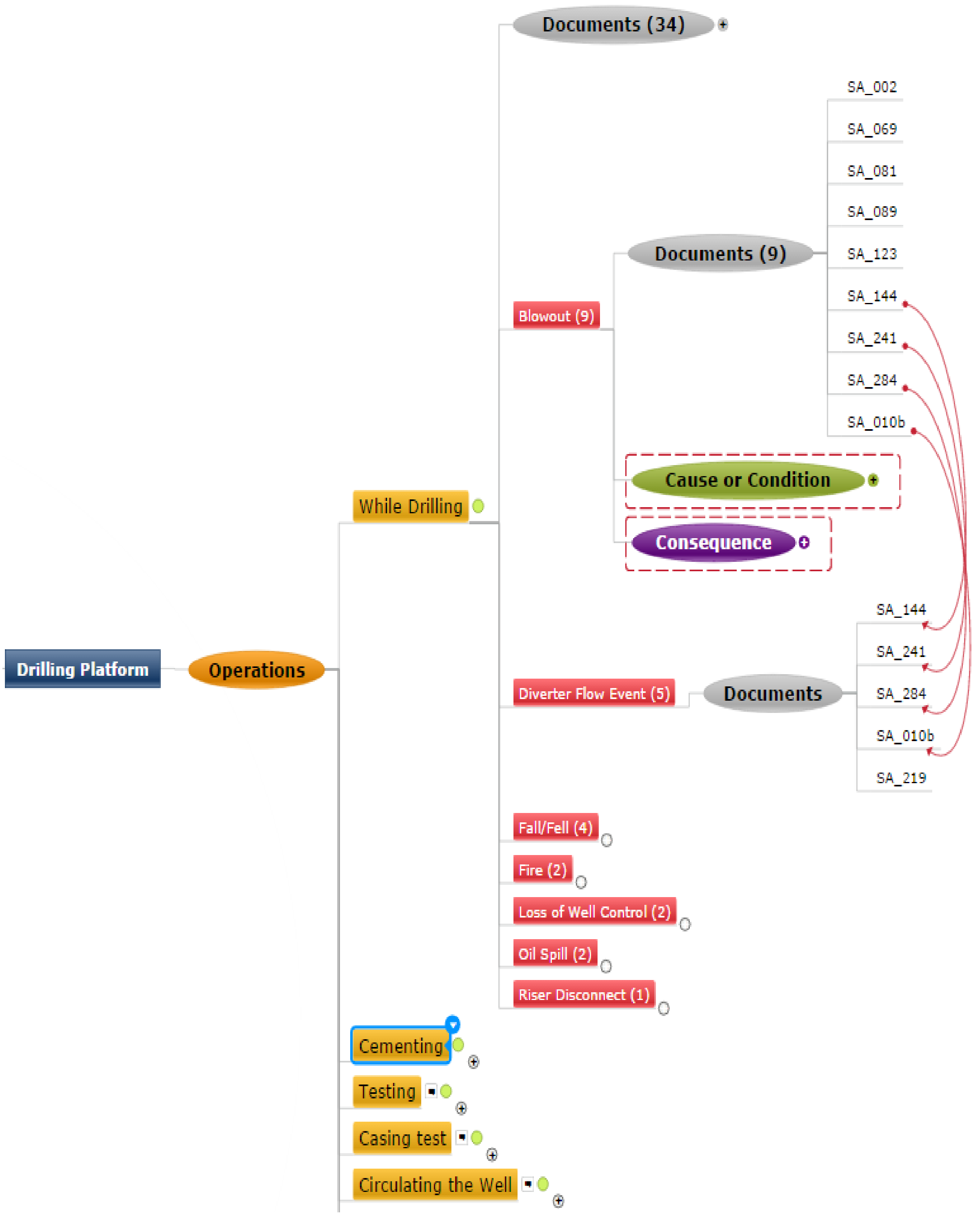

Figure A.4 Safety Alerts related to Blowouts and Safety Alerts related to Diverter Flow Events. Red arrows shows that one safety alert can contain more than one accident.

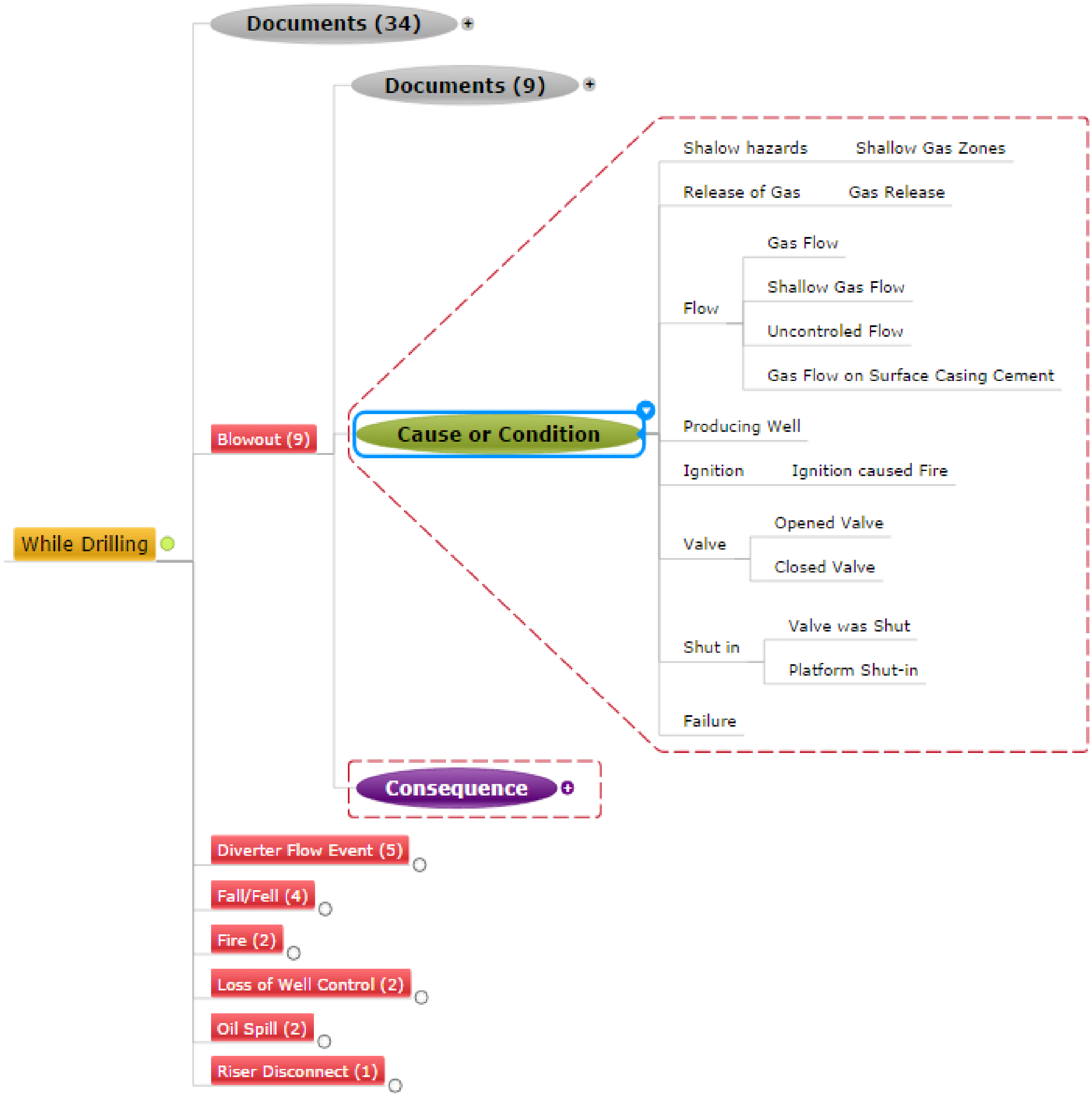

Figure A.5 Causes or conditions related to Blowouts that occurred while drilling operations.

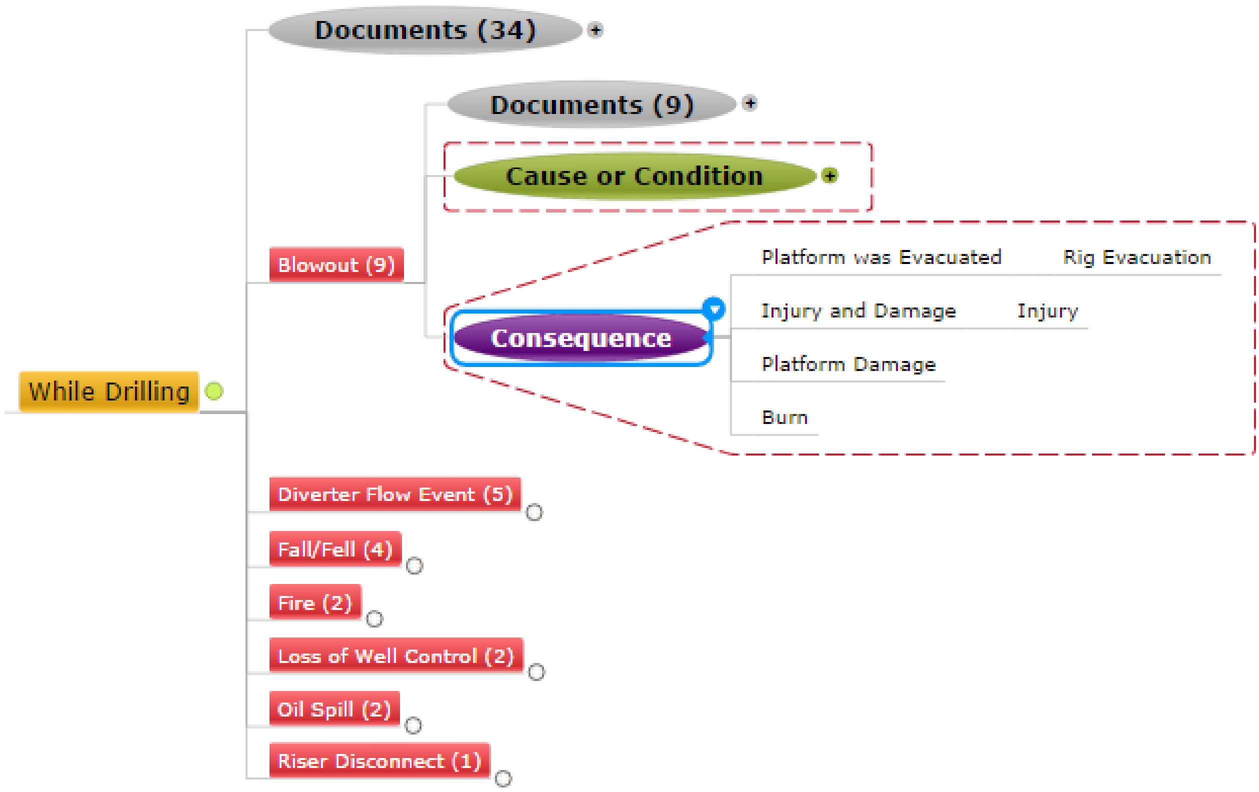

Figure A.6 Consequences of Blowouts occurred while drilling operations.

APPENDIX B – SEARCH EXPERIENCES

The following pages displays the results obtained by the searches described in Table 4.6.

Case # 1: BSEE Safety Alert, Blowout

BSEE safety alert blowout

Web Notícias Imagens Shopping Vídeos Mais Ferramentas de pesquisa

Aproximadamente 11.700 resultados (0,35 segundos)

Safety Alert for the Macondo Well Blowout | BSEE
www.bsee.gov/.../Safety-Alerts/National-Safety-Alert... ▾ Traduzir esta página
Safety Alert for the Macondo Well **Blowout**. 02/26/2014. National **Safety Alert** No. 10. November 10, 2011. On April 20, 2010, while the crew of the Mobile ...

[PDF] Safety Alert No. 210 - Blowout After Cementing ... - BSEE
www.bsee.gov/.../BSEE/.../Safety_Alerts/Safety%20... ▾ Traduzir esta página
U.S. Department of the Interior. Minerals Management Service. Gulf of Mexico OCS Region. **Safety Alert** No. 210. January 8, 2003. Contact: Lee Fowler.

[PDF] Safety Alert No. 205 – Blowout Results in Fatality ... - BS...
www.bsee.gov/.../BSEE/.../Safety_Alerts/Safety%20... ▾ Traduzir esta página
Gulf of Mexico OCS Region. **Safety Alert** No. 205. October 31, 2002. Contact: John McCarroll. (985) 853-5892. **Blowout** Results in Fatality and Injuries. Recently ...

[PDF] Safety Alert No. 024 - Shallow Gas Blowouts – One ... - ...
www.bsee.gov/.../BSEE/.../Safety_Alerts/Safety%20... ▾ Traduzir esta página
21 de fev de 2012 - OCS Operations **Safety Alert**. Shallow Gas **Blowouts** – One Rig Lost. Two offshore drilling rigs recently experienced **blowouts** after drilling into ...

USA: BSEE Issues Safety Alert Related to Macondo Blowout...
www.offshoreenergytoday.com/usa-bsee-issues-safet... ▾ Traduzir esta página
11 de nov de 2011 - The Bureau of Safety and Environmental Enforcement (**BSEE**) yesterday issued a **Safety Alert** relating to the Macondo well **blowout**. The Safety ...

BOEM Safety Alerts Page - OCS BBS
https://www.ocsbbs.com/safety.asp ▾ Traduzir esta página
Safety Alerts are posted by the **BSEE** to inform the offshore oil and gas industry of the ... 10, **Safety Alert** for the Macondo Well **Blowout**, 11/10/2011. 297, Potable ...

BP hit with additional BSEE violations - WorkBoat.com ...
www.workboat.com/component/content/article?id... ▾ Traduzir esta página
1 de jan de 2012 - The November **BSEE Safety Alert** regarding the Macondo **blowout** was distributed to oil and gas leaseholders working on the Outer Continental ...

[PDF] 1 July 16, 2015 Department of the Interior Bureau of Safe...
www.api.org/.../api-iadc-noia-ipaa-ooc-pesa-usoga-well-control-comment-l...
16 de jul de 2015 - Environmental Enforcement (**BSEE**) announced these proposed changes ... Continental Shelf—**Blowout** Preventer Systems and Well Control." ..... protocols that would define when and to whom internal **notifications** are made.

safety alert for the macondo well blowout - IOGP Safety Zone
safetyzone.iogp.org/SafetyAlerts/alerts/Detail.asp?ale... ▾ Traduzir esta página
A **safety alert** has been issued by the US Bureau of Safety and Environmental Enforcement (**BSEE**) for the Macondo Well **Blowout**. The alert can been viewed on ...

2nd Gulf rig blowout spurs calls to speed up safety rules
www.eenews.net/stories/1059985046 ▾ Traduzir esta página
25 de jul de 2013 - **BSEE** is in the process of revamping its regulations on **blowout** preventer standards in an effort to improve **safety**. In 2010, the **blowout** ...

1 2 3 4 5 6 7 8 9 10 Mais

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Safety Alert for the Macondo Well Blowout | BSEE

www.bsee.gov/Regulations-and-Guidance/Safety-Alerts/National-Safety-Alert-No--10/
Safety Alert for the Macondo Well **Blowout** 02/26/2014. National **Safety Alert** No. 10 November 10, 2011 On April 20, 2010, while the crew of the Mobile ...

[PDF] Safety Alert No. 070 - Blowout During Workover - BSEE

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts/Safety%20Alert%20No%2070.pdf
U.S. Department of the Interior Minerals Management Service Gulf of Mexico OCS Region Notice No. 070 June 12, 1978 OCS Operations **Safety Alert Blowout** ...

[PDF] Safety Alert No. 069 - Blowout -- Platform Loss - BSEE

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts/Safety%20Alert%20No%2069(2).pdf
U.S. Department of the Interior Minerals Management Service Gulf of Mexico OCS Region Notice No. 069 December 6, 1977 OCS Operations **Safety Alert** ...

[PDF] Safety Alert No. 205 -- Blowout Results in Fatality and ...

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts
/Safety%20Alert%20No%20205.pdf
Title: **Safety Alert** No. 205 -- **Blowout** Results in Fatality and Injuries Author: johnsder Subject: and Injury Created Date: 2/21/2012 4:36:55 PM

[PDF] Safety Alert No. 043 - Shallow Gas Blowout - BSEE

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts
/Safety%20Alert%20No%2043.pdf
U.S. Department of the Interior Minerals Management Service Gulf of Mexico OCS Region Notice No. 043 June 21, 1976 OCS Operations **Safety Alert** Shallow ...

[PDF] Safety Alert No. 123 - Shallow Gas Blowout - BSEE

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts
/Safety%20Alert%20No%20123.pdf
U.S. Department of the Interior Minerals Management Service Gulf of Mexico OCS Region Notice No. 123 January 5, 1984 Shallow Gas **Blowout** Conductor ...

[PDF] Safety Alert No. 210 - Blowout After Cementing Surface Casing

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts
/Safety%20Alert%20No%20210.pdf
Title: **Safety Alert** No. 210 - **Blowout** After Cementing Surface Casing Author: johnsder Created Date: 2/21/2012 4:38:39 PM

[PDF] Safety Alert No. 010 - Stem Blowout of Grove B-4 Ball Valves

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts
/Safety%20Alert%20No%2010.pdf
U.S. Department of the Interior Minerals Management Service Gulf of Mexico OCS Region Notice No. 010 August 15, 1974 OCS Operations **Safety Alert** Stem ...

[PDF] Safety Alert No. 111 - Blowout and Fire - BSEE Homepage

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts
/Safety%20Alert%20No%20111.pdf
U.S. Department of the Interior Minerals Management Service Gulf of Mexico OCS Region Notice No. 111 May 13, 1983 **Blowout** and Fire A pilot hole had ...

Current Safety Alerts | BSEE

www.bsee.gov/Regulations-and-Guidance/Safety-Alerts/Safety-Alerts/
Safety Alerts are tools used by BSEE to inform the offshore oil and gas industry of the circumstances surrounding an incident or a near miss. They ...

[PDF] Safety Alert No. 066 - Blowouts from Surface Casing ...

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts
/Safety%20Alert%20No%2066(1).pdf

The above could help prevent this type **blowout** where potential delayed gas flow conditions exist. The applicability of this **safety alert** should be ...

[PDF] Safety Alert No. 127 - Injury While Retesting Blowout ...

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts/Safety%20Alert%20No%20127.pdf
OCS Operations **Safety Alert** Injury While Retesting **Blowout** Preventers A chicksan-type fitting, equipped with a 2-inch threaded union and nipple, ...

[PDF] Safety Alert No. 024 - Shallow Gas Blowouts -- One Rig Lost

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts/Safety%20Alert%20No%2024.pdf
OCS Operations **Safety Alert** Shallow Gas **Blowouts** -- One Rig Lost ... The mudline **blowout** preventer was closed and kill operations were commenced. Gas ...

[PDF] U.S. Department of the Interior Minerals Management ...

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts/Safety%20Alert%20No%2081.pdf
U.S. Department of the Interior Minerals Management Service Gulf of Mexico OCS Region Notice No. 081 December 1, 1978 OCS Operations **Safety Alert** ...

[PDF] Trapped Pressure Beneath a Tubing Plug Blows Work String ...

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts/SA-306.pdf
Trapped Pressure Beneath a Tubing Plug Blows Work ... All personnel were mustered and the **blowout** ... A **Safety Alert** is a tool used by BSEE to inform ...

[PDF] Blowout and Fire - bsee.gov

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts/Safety%20Alert%20No%20199.pdf
U.S. Department of the Interior Minerals Management Service Gulf of Mexico OCS Region **Safety Alert** No. 199 November 15, 2001 Contact: Buddy Stewart

[PDF] U.S. Department of the Interior Minerals Management ...

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts/Safety%20Alert%20No%2089.pdf
U.S. Department of the Interior Minerals Management Service Gulf of Mexico OCS Region Notice No. 089 November 15, 1979 **Safety Alert Blowout** and Fire ...

[PDF] U.S. Department of the Interior Minerals Management ...

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts/Safety%20Alert%20No%20212.pdf
U.S. Department of the Interior Minerals Management Service Gulf of Mexico OCS Region **Safety Alert** No. 212 April 7, 2003 Contact: Jack Williams (504) ...

[PDF] Lower Marine Riser Package (LMRP) Connector Failure

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts/SA-303.pdf
Bureau of **Safety** and Environmental ... rigs as having **blowout** preventer ... A **Safety Alert** is a tool used by B SEE to inform the offshore oil and

Blowout Preventer Automatic Mode (Deadman) Activation

www.bsee.gov/Regulations-and-Guidance/Safety-Alerts/SA_294-pdf/
BOEMRE U.S. Department of the Interior Bureau of Ocean Energy Management, Regulation and Enforcement Gulf of Mexico OCS Region **Safety Alert Safety Ale** ...

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Case # 2: BSEE Safety Alert, Blowout, Drilling Rig

BSEE safety alert blowout drilling rig

Web Imagens Notícias Shopping Vídeos Mais Ferramentas de pesquisa

Aproximadamente 99.500 resultados (0,62 segundos)

Safety Alert for the Macondo Well Blowout | BSEE
www.bsee.gov/.../Safety-Alerts/National-Safety-Alert... Traduzir esta página
26 de fev de 2014 - On April 20, 2010, while the crew of the Mobile Offshore **Drilling** Unit ... Shortly after the **blowout**, hydrocarbons that had flowed onto the **rig** floor ignited ... This **Safety Alert** summarizes the investigative findings related to areas ...

[PDF] Safety Alert No. 024 - Shallow Gas Blowouts – One ... - ...
www.bsee.gov/.../BSEE/.../Safety_Alerts/Safety%20... Traduzir esta página
21 de fev de 2012 - OCS Operations **Safety Alert**. Shallow Gas **Blowouts** – One Rig Lost. Two offshore **drilling rigs** recently experienced **blowouts** after drilling into ...

Historical Safety Alerts | BSEE
www.bsee.gov/BSEE.../Historical-BSEE-Safety-Alert... Traduzir esta página
Safety Alerts are tools used by **BSEE** to inform the offshore oil and gas industry of the ... 10/23/2008, **Drilling Rig** Generator Electrical Equipment Fire .... 18/27/1997, List of **Safety Alerts** and Accident Investigation Reports Concerning **Blowouts**.

[PDF] Shallow-Gas Blowout and Rig Evacuation - BSEE
www.bsee.gov/...and.../Safety-Alerts/SA_241-pdf/ Traduzir esta página
Safety Alert No. 241. July 6, 2006. Contact: Glenn Woltman. (504) 736-2438. Shallow-Gas **Blowout** and **Rig** Evacuation. While **drilling** below drive pipe in open ...

[PDF] wo/o/ v - BSEE
www.bsee.gov/Inspection-and.../86-0101-pdf/ Traduzir esta página
A. **Safety Alerts**. B. OCS Order No. 2 ... A serious **blowout** and fire occurred on September 14, 1984, on the semisubmersible **drilling rig** Zapata ... panel members visited the **drilling rig** in a shipyard at Brownsville, Texas, on October 5,. 1984.

Safety Alert No. 081 - Blowout - BSEE
www.bsee.gov/.../BSEE/.../Safety_Alerts/Safety%20... - Traduzir esta página
21 de fev de 2012 - OCS Operations **Safety Alert**. **Blowout**. While **drilling** a hole for a water injection well, the bit drilled ... The **platform** was shut in and evacuated.

Safety Alert No. 199 - BSEE
www.bsee.gov/.../BSEE/.../Safety_Alerts/Safety%20... - Traduzir esta página
21 de fev de 2012 - effort to divert the flow of gas away from the platform and rig. ... source and caused extensive damage to the platform and **drilling rig**. The MMS investigation of the accident revealed in part that, while the source of the **blowout**, ...

[PDF] 1 July 16, 2015 Department of the Interior Bureau of Safe...
www.api.org/.../api-iadc-nola-ipaa-ooc-pesa-usoga-well-control-comment-l...
16 de jul de 2015 - **Equipment** & Services Association (PESA), and the US Oil and Gas Association respectfully ... Environmental Enforcement (**BSEE**) announced these proposed changes on April ... Continental Shelf—**Blowout** Preventer Systems and Well Control." ... the **Drilling Safety** Rule and the **Safety** and Environmental ...

Oil and Gas International - Health Safety Environment ...
www.oilandgasinternational.com/directories/hse.aspx Traduzir esta página
... **platform** - (11/15/2015) Serious injury in **blowout** at Arrow **Drilling** well in Texas ..... (5/29/2014) US **BSEE** & Coast Guard issue DP **rig safety alert** - (5/29/2014) ...

One-Third of US Gulf Drilling Rigs to Be Inspected for Faulty ...
www.maritime-executive.com/.../One-Third-of-US-... Traduzir esta página
8 de fev de 2013 - A **safety alert** issued to offshore **drillers** on Jan. ... Gulf of Mexico appear to have **equipment** that uses the bolts, according to **BSEE** officials. ... according to analysts with Dahlman Rose & Co., but if a **blowout** preventer has to be ...

Sandvik Drilling Rigs

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[PDF] Safety Alert No. 024 - Shallow Gas Blowouts -- One Rig Lost

www.bsee.gov/uploadedFiles/BSEE/Regulations/Safety_Alerts/Safety%20Alert%20No%2024.pdf
Two offshore **drilling rigs** recently experienced **blowouts** after **drilling** into shallow gas zones. ... **Safety Alert** No. 024 - Shallow Gas **Blowouts** ...

BSEE Homepage | BSEE

www.bsee.gov/
Testing oil spill containment equipment is a critical part of BSEE's mission protecting **safety** and the environment on the ... **Safety Alerts**; Internal ...

[PDF] UNITED STATES DEPARTMENT OF THE INTERIOR BUREAU OF SAFETY ...

www.bsee.gov/uploadedFiles/BSEE/Inspection_and_Enforcement/Accidents_and_Incidents/acc_repo/2015/EB%20643%20Anadarko%2021%20Sep%202015.pdf
HISTORIC **BLOWOUT** UNDERGROUND DEVERTER ... BUREAU OF **SAFETY** AND ENVIRONMENTAL ENFORCEMENT ... monitoring system to **alert** the winch operator the ...

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Case # 3: BSEE Safety Alert, Blowout, Drilling Rig, Cementing

bsee safety alert blowout drilling rig cementing

Web Imagens Notícias Shopping Vídeos Mais ▾ Ferramentas de pesquisa

Aproximadamente 60.300 resultados (1,09 segundos)

Safety Alert for the Macondo Well Blowout | BSEE
www.bsee.gov/.../Safety-Alerts/National-Safety-Alert... ▾ Traduzir esta página
26 de fev de 2014 - On April 20, 2010, while the crew of the Mobile Offshore **Drilling** Unit (MODU) ... Shortly after the **blowout**, hydrocarbons that had flowed onto the **rig** floor ignited in two ... This **Safety Alert** summarizes the investigative findings related to areas of ... The operator did not follow the **cementing** recommendations ...

Historical Safety Alerts | BSEE
www.bsee.gov/BSEE.../Historical-BSEE-Safety-Alert... ▾ Traduzir esta página
Safety Alerts are tools used by **BSEE** to inform the offshore oil and gas industry of the circumstances surrounding an ... 10/23/2008, **Drilling Rig** Generator Electrical Equipment Fire ... 11/08/2003, **Blowout** After **Cementing** Surface Casing.

[PDF] Safety Alert No. 043 - Shallow Gas Blowout - BSEE
www.bsee.gov/.../BSEE/.../Safety_Alerts/Safety%20... ▾ Traduzir esta página
21 de fev de 2012 - OCS Operations **Safety Alert** ... A shallow gas **blowout** recently occurred on an offshore platform **drilling rig**. A string of 10" casing had been run and **cemented** at 2716'. After 5 hours ... **blowout** preventer was removed. During ...

[PDF] wo/o/ v - BSEE
www.bsee.gov/...and-Enforcement/.../86-0101-pdf/ ▾ Traduzir esta página
A. **Safety Alerts** ... A serious **blowout** and fire occurred on September 14, 1984, on the ... panel members visited the **drilling rig** in a shipyard at Brownsville, Texas, on October 5,. 1984. .... The Halliburton **cementing** unit was routed to the kill line.

Safety Alert No. 199 - BSEE
www.bsee.gov/.../BSEE/.../Safety_Alerts/Safety%20... - Traduzir esta página
21 de fev de 2012 - effort to divert the flow of gas away from the platform and rig. ... an unknown source and caused extensive damage to the platform and **drilling rig**. The MMS investigation of the accident revealed in part that, while the source of the **blowout**, namely shallow gas, was identified through well log data, the **cement** ...

[PDF] Investigation of Blowout Main Pass Block 91 ... - BSEE
www.bsee.gov/...Enforcement/.../2008-053-pdf/ ▾ Traduzir esta página
23 de ago de 2007 - **Safety Alert**. 15. Appendix ... feet to 6,595 feet with perforations within the **cement** packer into two producing intervals. ... Wyoming **drilling rig** was contracted to drill a relief well, OCS-G 14576 Well No 3. The relief well was ...

Interior Department Releases Proposed Well ... - BSEE
www.bsee.gov/BSEE.../Interior-Department-Releases... ▾ Traduzir esta página
13 de abr de 2015 - "This rule builds on enhanced industry standards for **blowout** preventers to comprehensively address well design, well control and overall drilling **safety**." ... casing, **cementing**, real-time well monitoring and subsea containment. ... There are more floating deepwater **drilling rigs** working in the Gulf of Mexico ...

OFFSHORE DRILLING: Gulf operations still unsafe despite ...
www.eenews.net/stories/1060000793 ▾ Traduzir esta página
5 de jun de 2014 - The accident at the Deepwater Horizon **rig** that killed 11 workers and ... the Bureau of **Safety** and Environmental Enforcement's (**BSEE**) requirement for all ... a new theory on why the Transocean Ltd. **rig's blowout** preventer failed. ... between the surface and a **cement** plug deep in the well put in place to keep ...

Deepwater Horizon - Transocean Oil Rig Fire - gCaptain
gcaptain.com/.../4805-deepwater-horizon-transocean... ▾ Traduzir esta página
8 de nov de 2011 - • failure to perform bottoms up circulation before **cementing** ... the steam driven **drilling rigs**, talking to the roughnecks, hanging around ..... **BSEE**: **Safety Alert** on the Deepwater Horizon Explosion and Spill ... 066, September 26, 1977, "**Blowouts** from Surface Casing – Conductor Casing Annulus"

Landmark Incidents | EU Offshore Authorities Group
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All **alerts**... ... A pressure **safety** valve was removed from compressor A for recalibration ... down due to a perceived lack of authority, even though personnel could **see** ... The **rig** was **drilling** a natural gas well when a gas **blowout** occurred during **drilling** ops. ... The inquiry further noted that the initial **cementing** problems were ...

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[PDF] Draft Environmental Assessment - bsee.gov

www.bsee.gov/uploadedFiles/BSEE/Regulations_and_Guidance/Proposed_Rules/Well_Control_Rule/BOP%20Draft%20EA%204-8-2015.pdf
... well control, casing, **cementing**, ... **Oil** and Gas **Blowout** ... **Rig** and equipment movement reports for Mobile Offshore **Drilling** Units (MODUs), ...

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