Safety Science 48 (2010) 615–624

Contents lists available at ScienceDirect

Safety Science

journal homepage: www.elsevier.com/locate/ssci

A safety culture maturity model for petrochemical companies in Brazil

Anastacio Pinto Goncalves Filho [a,*], Jose Celio Silveira Andrade [b,1], Marcia Mara de Oliveira Marinho [c,2]

[a] Ministry of Labour and Employment, Rua Valdemar Falcao, 889 Apt. 301, Brotas, Salvador, Bahia, CEP 40.296-710, Brazil
[b] School of Management, Bahia Federal University, Av. Reitor Miguel Camon, s/n, Vale do Canela, Salvador, Bahia, CEP 40.110-100, Brazil
[c] Department of Environmental Engineering, Bahia Federal University, Rua Aristides Novis, 2, Federacao, Salvador, Bahia, CEP 40.110-100, Brazil

ARTICLE INFO

Article history:
Received 29 May 2009
Received in revised form 21 November 2009
Accepted 12 January 2010

Keywords:
Safety culture
Safety culture maturity model
Organisational

ABSTRACT

A framework to measure safety culture maturity in the Brazilian oil and gas companies was formulated based on the model of Hudson (2001). Following a review of the safety culture literature, a questionnaire was designed to measure five aspects of organisational safety indicative of five levels of cultural maturity. The questionnaire was completed by the safety managers of 23 petrochemical companies based in Camacari, Bahia, Brazil and they were interviewed one month later. The reliability of the questionnaire was tested by asking the same questions in an interview and comparing the results (alternate forms reliability). The correlation coefficients between the questionnaire and interview scores on each dimension ranged from $r = 0.7$ to 0.9, demonstrating good reliability of the measures used. The research findings demonstrated that the 23 companies studied showed characteristics of different levels of safety culture maturity. Most scores were at the level of proactive. The model of Hudson (2001) and the revised framework and questionnaire were found to be practical to use, making it possible to identify levels of safety culture maturity in the context of the Brazilian petrochemical industry.

1. Introduction

Despite Brazil having one of the major oil and gas companies in the world and the largest integrated industrial complex in the southern hemisphere, there is no theoretical or empirical research on safety culture in industry in the country. The research reported here has the aim of designing a framework and measurement tool to identify stages of safety culture maturity for application in Brazilian industry. It is known that national culture influences organisational culture (Hofstede and Hofstede, 2005). However, Mearns and Yule (2008) argue that there is little research on the influence of national culture on safety culture. Furthermore safety culture studies have been typically carried out in Western environments (Guldenmund, 2000) and we have little to guide us when we step outside the comfort zone of the Western cultural environment that has been studied in some detail (Hudson, 2007).

In the research reported here, the concept of safety culture adopted was that of Hopkins (2005) who proposed that safety culture is about organisational collective practices and is a characteristic of groups and of organisations. He argues that it is more useful than the idea of culture as values, because it provides a practical way to bring about culture change. This view of safety culture reinforces the idea that culture is specific to a group or an organisation, since the practices in one organisation are unlikely to be relevant in their entirety to another. This research focused on aspects that reflect what the organisation *has*, such as strategic plans and action plans that integrate safety into all aspects of an organisation's activities, presence and quality of the organisation's risk control systems, presence and quality of an organisation's safety management information system, the extent to which an organisation's safety management systems are reviewed and the extent to which every employee receives high quality integrated job and safety training, which are the elements that constitute a good foundation for safety in an organisation (IAEA, 2002a). These aspects were analyzed initially from collected data from safety managers, the proper people in organisations to provide information about them.

One approach to understanding industrial safety culture is the safety culture maturity model which focuses on these organisational characteristics and which may be suitable for cultural adaptation in Brazil. In order to test the applicability of this model 23 national and multi-national petrochemical companies based in the integrated industrial complex were chosen.

2. Safety culture maturity models

According to Schein (2004a), there are three stages of organisational culture evolution: Founding and Early Growth, Midlife and Maturity/Decline. In an organisation's Founding and Early Growth

* Corresponding author. Tel.: +55 71 33564575/99877015; fax: +55 71 33290848.
E-mail addresses: anastaciofilho@ufba.br, anastaciopinto@uol.com.br (A.P.G. Filho), celiosa@ufba.br (J.C.S. Andrade), marma@ufba.br (Marcia Mara de Oliveira Marinho).
[1] Tel.: +55 71 32837340.
[2] Tel.: +55 71 32839791.

0925-7535/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ssci.2010.01.012

stage, the main cultural thrust comes from the founders and their assumptions. At the midlife stage, the leaderships do not have same options as the founder and owners. At this stage, the culture defines leadership more than leadership creates culture, all organisations undergo a process of differentiation as they grow and can work on subculture, and the objective is to socialize the culture. At the Maturity/Decline stage, the continued success creates strongly held shared assumptions and thus a strong culture. Each stage requires different culture change mechanisms and different leadership requirements.

Westrum (1993, 2004) created a model to identify types of organisational culture based on how an organisation processes information. In his model, there are three types of culture: Pathological, Bureaucratic and Generative. He considers the flow of information the most critical issue for organisation safety.

According to the International Atomic Energy Agency (IAEA, 2002a), three stages of development of safety culture seem to occur in organisations. Each stage involves a different awareness of the effect on safety of human behaviour and attitudes. The characteristics of each stage are described below. They may be used by an organisation to diagnose which stage reflects its current state most accurately.

At stage 1, an organisation sees safety as an external requirement and not as an aspect of conduct that will allow it to succeed. The external requirements are those of government, the legal framework and the regulatory bodies. There is little awareness of the behavioural and attitudinal aspects of safety. Safety is seen as a technical issue, to be achieved by compliance with rules and regulations.

An organisation at stage 2 considers safety to be an important organisational goal, even in the absence of external requirements. Although there is growing awareness of behavioural issues, this aspect is largely missing from safety management, which generally concentrates on technical and procedural solutions. Safety is dealt with in terms of targets or goals, with accountabilities for achieving the goals specified. organisations at this stage often discover that after a period of time, when safety trends have improved, a plateau is reached. At stage 3 an organisation has adopted the idea of continuous improvement and applied the concept to safety. There is a strong emphasis on communication, training, management style and improving efficiency and effectiveness. People within the organisation understand the impact of cultural issues on safety. The three stages should not be considered as totally distinct. It is possible for an organisation, at any one time, to exhibit characteristics associated with several, or all, of the stages (IAEA, 2002a).

Fleming (2001) developed a model of maturity of safety culture with the objective of helping organisations identify the level of maturity of their safety culture. His model was based on the capability maturity models used in software engineering organisations and has five levels of maturity: emerging, managing, involving, cooperating and continually. There are ten elements namely management commitment and visibility; communication; productivity versus safety; learning organisation; safety resources; participation; shared perceptions about safety; trust; industrial relations job satisfaction and training. An organisation's level of safety culture maturity is determined on the basis of the ratings on these elements. Deciding which level is most appropriate is based on the average level achieved by the organisation being evaluated. It is proposed that organisations progress sequentially through the five levels, by building on the strengths and removing the weaknesses of the previous level. Fleming's (2001) safety culture maturity model is only of relevance to organisations that fulfil a number of specific criteria that include:

- An adequate Safety Management System.
- Technical failures are not causing the majority of accidents.
- The company is compliant with health and safety law.
- Safety is not driven by the avoidance of prosecution but by the desire to prevent accidents.

Both Fleming's (2001) safety culture maturity model and stages of maturity of safety culture proposed by IAEA (2002a) were developed as a diagnostic tool. Yet they are models that lack empirical evidence to support them, since, no available data indicates that all organisations follow a sequential maturation and also that the use of averages to determine the level of maturity is appropriate. Fleming (2001) himself cautions that his safety culture maturity requires a significant amount of research before it can be used in this way.

Hudson (2001) also proposed a safety culture maturity model, based on the one originally developed by Westrum (1993) for the evolution of safety culture from the Pathological first stage through to an idealistic end-stage called Generative. Two additional levels, reactive and proactive, were initially proposed by Reason (1997) as extensions of Westrum's original typology. The model extended to five stages in a sequence and replacing the bureaucratic label with calculative. Fig. 1 shows the developmental stages of Hudson's (2001) model.

The descriptions of each stage of development of safety culture according to Hudson (2003) are as follows:

> *Pathological*: safety is a problem caused by workers. The main drivers are the business and a desire not to get caught by the regulator.
> *Reactive*: organisations start to take safety seriously but there is only action after incidents.
> *Calculative*: safety is driven by management systems, with much collection of data. Safety is still primarily driven by management and imposed rather than looked for by the workforce.
> *Proactive*: with improved performance, the unexpected is a challenge. Workforce involvement starts to move the initiative away from a purely top down approach.
> *Generative*: there is active participation at all levels. Safety is perceived to be an inherent part of the business. Organisations are characterised by chronic unease as a counter to complacency.

Parker et al. (2006) then designed a framework that could be used by organisations to understand their safety culture maturity using Hudson's (2001) model. The framework was developed through interviews with 26 senior oil executives working in a range of multi-national oil companies and contracting companies. Interviewees were asked to describe how an oil company would function in terms of 11 tangible and seven less tangible aspects of safety culture following a distinction pointed out by Zohar (2000). Tangible or concrete aspects included the system for benchmarking and auditing safety performance, and the way in which work is formally planned. Less tangible or abstract aspects involved the perceptions of the workforce.

They broke down the qualitative descriptions of this framework into their constituent statements and used them to develop a questionnaire to investigate workforce perceptions of safety culture (Lawrie et al., 2006). Fifty-nine out of 500 employees (11.8%) participated in the study which took place at a refinery and chemical plant. According to the authors, the responses of the questionnaire allowed an assessment of how far the statements formed statistically coherent factors and results showed that some, but not all, of the descriptions of the levels of safety culture were statistically reliable when broken down and submitted to principal components analysis. In general, the items grouped together in ways that did not contradict the 5-level framework. In other words, the respondents did not perceive features from the more advanced

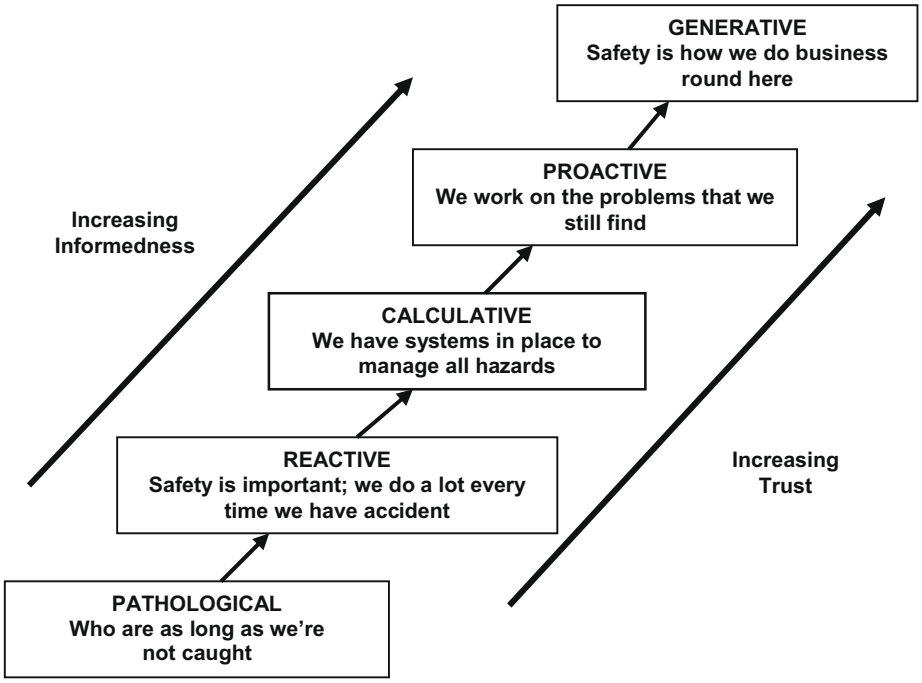

Fig. 1. Safety culture model of Hudson (2001).

levels of safety culture (generative and proactive) associated with a less advanced level (reactive and pathological).

Geert Hosfstede conducted one of the most influential studies on national and organisational culture based on work at IBM in more than fifty countries around the world. The empirical analysis resulted in a concise framework of dimensions for differentiating national culture (Hofstede and Hofstede, 2005). The five dimensions found to differentiate national culture groups were: Power Distance, Uncertainty Avoidance, Individualism/Collectivism, Masculinity/Femininity and Long-term Orientation (added later when the study was extended to cultures of the Far East). He found that multi-national companies develop a hybrid culture that reflects at the same time both the multi-national and the national cultures. Therefore, the national culture impacts on the organisational culture.

According to Hofstede and Hofstede (2005), in general, South American culture, like in Brazil, has high Power Distance, strong Uncertainty Avoidance and Collectivism. In contrast, Western culture, such as in Great Britain has opposite characteristics, as follows: low Power Distance, weak Uncertainty Avoidance and Individualism. Both South American and Western culture are more Masculinity than Femininity. Brazilian culture concerning Masculinity/Femininity is undefined. In high Power Distance cultures, superiors are encouraged to wield and exercise power. Subordinates are expected to be passive, the organisation is hierarchical and decision-making is decentralised. In low Power Distance cultures, however, there is a closer relationship between supervisors and subordinates, organisational structures are flatter and subordinates are more involved in decision-making. Individualism, everyone is expected to look after him or herself, as opposed to Collectivism, where strong cohesive groups protect and support their members. Masculinity, where people value money, material success and progress over relationships versus Femininity, where people value other people and relationships over material success.

Mearns and Yule (2008) found in a study carried out in a multinational engineering organisation operating in six countries that, in many ways, the values of globalization, embodied by management practices that are largely uniform across national contexts are stronger than locally-held cultural values in determining behaviour within a prescribed environment.

The framework from Hudson's (2001) safety culture maturity model has been applied in petrochemical, oil and health care companies; however, it has been applied in countries such as Oman (Hudson and Willekes, 2000) and the United Kingdom (Hudson, 2007) with national cultures which are very different from Brazilian culture. The present study thus focuses on answering the following question: Is Hudson's (2001) safety culture model also suitable for adaptation for a country like Brazil?

3. Developing the framework

The model of culture maturity used in this research was based on that developed by Hudson (2001). This model is more suitable for use in Brazil than Fleming's (2001) model because the latter's criteria (e.g. an adequate Safety Management System, technical failures not causing the majority of accidents, the company is compliant with health and safety law) constrain it for general use in Brazil. The three stages of development of safety culture of the IAEA (2002a) are not sufficiently comprehensive. Hudson's model was slightly modified, by renaming the calculative stage as bureaucratic (as in Westrum's (1993) model) and the generative stage as sustainable, because these terms are easier to understand and more familiar to safety managers in Brazil.

A framework to identify the stages of maturity of an organisation's safety culture was built from Hudson's (2001) model and from the five dimensions described below. The framework of Parker et al. (2006) was not used because it is very long with 18 dimensions and would be impractical to manage.

The dimensions that form the framework to identify the stages of maturity of safety culture in organisations were chosen from the literature on safety culture. A literature review of 19 studies (Cheyne et al., 1998; Cox and Cheyne, 2000; Davies et al., 2001; DeJoy et al., 2004; Ek et al., 2007; Fleming, 2001; Flin et al., 2000; Garcia et al., 2004; Glendon and Stanton, 2000; Hahn and Murphy, 2007; Mearns et al., 2001, 2003; Neal et al., 2000; Reason, 1997; Rundmo,

2000; Rundmo and Hale, 2003; Varonen and Mattila, 2000; Williamson et al., 1997; Zohar, 1980) of safety culture was conducted to identify the component dimensions of which the most frequently cited were chosen. It is unlikely these will exactly represent all the dimensions of the concept of safety culture. However, to attempt to represent all dimensions of one theoretical concept in a single measurement would be impossible. The five dimensions chosen were used both by Fleming's (2001) model and by Parker et al.'s (2006) framework.

The description for each of the five dimensions was derived from the literature as shown below:

Information: describes an organisation which has a formal system that allows its employees to inform about any near misses and accidents and the confidence the employees have in the organisation, thus feeling comfortable enough to report these. These are essential aspects of an informed culture and a just culture (Reason, 1997). It also describes which indicators the organisation has in order to improve the performance of safety at the workplace (Hudson, 2003; IAEA, 2002b).

Organisational Learning: involves the way the organisation deals with the information, how the organisation analyses the accidents and near misses at the workplace, as well as if the organisation keeps the employees informed about these events (IAEA, 2002b; Reason, 1997).

Involvement: describes how the organisation leads the employees to a growing participation in safety issues, in accident analysis and in reviewing procedures and rules. It also includes if the employees participate in safety committees and safety meetings (Choudhry et al., 2007; Gordon et al., 2007).

Communication: describes how, when and what to communicate regarding safety issues to employees. Also, if there is an open communication channel between employees and managers. It also describes if the communication reaches the employees and is understood by them (Cooper, 1998; Glendon and Stanton, 2000; Mearns et al., 2003; Olive et al., 2006; Westrum, 2004).

Commitment: describes the support given by the organisation as far as Health and Safety is concerned: planning, priorities, training, auditing, contractor, rewards, investment, procedures and teaming. It also describes there is a Health, Safety and Environment Management System. Truthful commitment means more than writing political statements to say that Health and Safety are important, it needs to have coherence between words and reality (DeJoy et al., 2004; Flin et al., 2000; IAEA, 2002b; Olive et al., 2006).

The framework describes how each one of the five dimensions is treated in each one of the five stages of the revised model. This description was based on the literature (Fleming, 2001; Hudson, 2003; Parker et al., 2006) and on the experience of the researcher who has worked for the Brazilian government as a safety auditor for 10 years and has professional experience of 11 years, working as an engineer for an oil and gas company. Some dimensions have the same description in different stages because their treatment in the different stages is the same.

4. Method

4.1. Questionnaire

Each item of the framework was used as a statement to develop a questionnaire to investigate how each one of five dimensions was treated in the organisations studied. The number of questions for each one of five dimensions varied with the number of items in the framework (see Appendix A). Each item represented one stage: 1 – Pathological, 2 – Reactive, 3 – Bureaucratic, 4 – Proactive and 5 – Sustainable. The questionnaire had 22 questions: 14 questions with five items and eight questions with four items, hence totalling 102 items. For each question, the respondents were required to select the item that best represented the position for their company. Table 1 shows one question with five items relating to the five levels of maturity for the dimension information.

Table 1
One of the questions with five items for information dimension.

Question 1 – relating to how the unusual events (near miss, accidents…) are reported
The unusual events which occur in the organisation are not reported by the employees
Only the serious accidents are reported by the employees
All the unusual events which occur in the organisation are reported by the employees
Most of the unusual events which occur in the organisation are reported by the employees
Most of the unusual events which occur in the organisation are not reported by the employees

4.2. Pilot test

A pilot test was undertaken by applying the questionnaire with the proposed framework to five safety managers of five different petrochemical companies, aiming to check its usefulness and to avoid misunderstanding. As a result, some minor changes were made on the framework and in the questionnaire in order to make it practical and understandable. Appendix A shows the revised version of the framework with the description of how each one of five dimensions is treated at each one of the five stages of maturity of safety culture.

4.3. Respondents

The questionnaire was sent by email to safety managers of the 10 national and 13 multi-national petrochemical companies of the Camacari integrated industrial complex. All 23 safety managers answered the questionnaire and returned it to the researcher by email two months later.

4.4. Alternate forms reliability analysis of the questionnaire – Interviews

Alternate forms reliability involves comparing two different versions of the same measure (Dane, 1990). The 23 safety managers who answered the questionnaire were interviewed by the researcher one month later in order to compare their answers from the questionnaire. Each interviews lasted 60 min on average. The scores of each dimension on the questionnaire were obtained from interviewees' responses. As the data are non-parametric, Kendall's tau, τ, (Field, 2005) was used to verify if the scores from questionnaire correlated with the scores from the interview.

The correlations are shown in Table 2. The correlations are between 0.7 and 0.9 and they are significant, indicating good alternate forms reliability.

5. Results

5.1. Maturity of safety culture

Table 3 shows the percentage of answers from 22 questions for each one of the five dimensions from 23 safety managers. If we

Table 2
Correlation between scores from questionnaire and interview.

Dimensions	Kendall' tau, τ
Information	0.878**
Organisational Learning	0.929**
Involvement	0.773**
Communication	0.805**
Commitment	0.849**

** Correlation is significant at the 0.01 level.

Table 3
Maturity of safety culture scores for each one of the dimensions.

	Pathological (%)	Reactive (%)	Bureaucratic (%)	Proactive (%)	Sustainable (%)
Information	2	0	0	44	54
Organisation Learning	0	0	1	58	41
Involvement	0	0	4	44	52
Communication	9	0	1	55	35
Commitment	1	4	13	9	73

Table 4
Stages of maturity of multi-national and national company.

	Pathological (%)	Reactive (%)	Bureaucratic (%)	Proactive (%)	Sustainable (%)
Multi-national	1	2	5	34	58
National	3	1	7	48	41

consider the Camacari integrated industrial complex as if it were one organisation, it presents characteristics from the lowest stage (pathological) to the highest stage (sustainable) of maturity of safety culture, although it is clear that the modal (most frequent) choice is for proactive and sustainable stages.

The information, communication and commitment dimensions present characteristics of the two extreme stages of maturity: pathological and sustainable. Besides all dimensions present characteristics from at least three stages (pathological or bureaucratic, proactive and sustainable) of maturity of safety culture and the commitment dimension for these companies presents characteristics of all five stages of maturity of safety culture. These results are significant despite the low percentage at the extreme lower end of the cultural maturity scale, because they show that a company can be at different stages of maturity of safety culture in the same dimension.

The results (see Table 4) showed that the 13 multi-national companies have more characteristics of the sustainable stage than the 10 national companies and the national companies have more characteristics of the pathological and bureaucratic stage than multi-national companies, however, a Mann–Whitney test (Field, 2005) indicated no significant differences between the two groups regarding the stages of maturity ($U = 11.50$, $p > 0.05$, $r = -0.05$).

6. Discussion

6.1. Reliability

The use of interviews as a method for alternate forms reliability analysis was successful even for a relatively small sample ($n = 23$). The questionnaire and the framework have overall good alternate forms reliability.

6.2. Stages of maturity of safety culture

There are several possible reasons for the modal (most frequent) choice being the proactive and sustainable stages. First, the companies studied have been working on improving safety for along time and have achieved a high level of safety performance. The lost-time accident rate at the Camacari integrated industrial complex is one occurrence for every million man-hours worked, compared with 17 occurrences for other industries in Brazil. Therefore the pathological and reactive stages of maturity of safety culture may now be almost extinct for them.

Second, as already mentioned, all the companies studied are settled at Camacari integrated industrial complex and they work with a Central Committee. This Committee has the role of promoting, integrating and stimulating collective actions for all companies of the integrated industrial complex. One of these actions refers to the practice of health and safety in the industrial complex as a whole. Moreover, there are external rewards for increasing motivation for safety because the Central Committee rewards the companies with the best safety performance.

Third, one important point is the presence of communities located near the complex. The companies are aware of the risk they represent to those communities (such as explosions and toxic gas leaks) and tend to promote the highest safety performance.

Finally, it may be that the statements included in the framework and in the questionnaire do not accurately reflect the stages of maturity of the safety culture that they were designed to measure. However, to test the dimensional validity of the framework (e.g. information) would need to have an independent means of the assessing each of the dimensions. To examine validity of the maturity stages would require a test showing that the maturity scores were correlated with companies' safety records. It is also important to apply the framework to other kinds of industry. If the framework can be shown to make sense to organisations in other industries, its theoretical basis will be strengthened by the support of its content validity.

6.3. Different stages of maturity of safety culture

The different stages of maturity found in this Brazilian sample are consistent with the safety culture maturity concept in that safety culture does not develop at the same pace in all companies and in all dimensions (Fleming, 2001; IAEA, 2002a). Hudson and Willekes (2000) have found similar results in the oil industry in other countries, e.g. Oman.

The organisational culture does not extend equally into all parts of the organisational system and does not exert a consistent effect. Actions to improve safety culture may exert stronger effects in some areas rather than others or they may not exert the same effects in all areas. Differences between the different stages of safety culture have to be taken into account when trying to improve performance. It is crucial to know where the organisation is in relation to its culture if you want to change it. This finding means also that an organisation may not assert that it has a safety culture without having passed through all the stages of maturity of safety culture and reached the stage in which safety is an overriding priority. As a result, a safety culture can only be taken seriously at the highest stage of development (Hopkins, 2005; Hudson et al. (2000); IAEA, 1991; Reason, 1997). According to Schein (2004a), little variation within a cultural unit is found. He notes, "if there is no consensus on key issues of language, thought, practices, etc. then, by definition, there is no culture" (Schein, 2004b, p. 980). This challenges the idea that all organisations have a safety culture which may vary in its effectiveness. This perspective works with a different type of conceptualisation of organisational culture and safety culture in particular that focuses on the lack of consensus and that

Table 5
Framework to identify maturity of safety culture in information (Translated to English).

Information				
Pathological	Reactive	Bureaucratic	Proactive	Sustainable
1. The unusual events which occur in the organisation are not reported by the employees 2. There is not a formal system that allows the employees to inform any unusual events, including accidents and serious ones, occurred in the organisation 3. The employees do not inform any unusual events occurred because they do not feel comfortable enough in relation to the organisation 4. There are no performance indicators of safety at work	1. Only the serious accidents are reported by the employees 2. There is a formal system which allows the employees to inform only the serious accidents occurred in the organisation 3. The employees do not inform any unusual events occurred because they do not feel comfortable enough in relation to the organisation 4. The only performance indicators of safety at work are the serious accidents occurred in the workplace	1. Most of the unusual events which occur in the organisation are not reported by the employees 2. There is a formal system that allows the employees to inform only the accidents, including the serious ones, occurred in the organisation 3. The minority of the employees feel comfortable enough to inform the unusual events occurred in the organisation 4. The only performance indicators of safety at work are the accidents and work-related illnesses rates	1. Most of the unusual events which occur in the organisation are reported by the employees 2. There is a formal system that allows the employees to inform all the unusual events, including accidents and serious accidents, occurred in the organisation 3. The majority of the employees feel comfortable enough to inform the unusual events occurred in the organisation 4. The organisation has other performance indicators of safety at work as well as the accidents and work-related illnesses rates	1. All the unusual events which occur in the organisation are reported by the employees 2. There is a formal system that allows the employees to inform all the unusual events, including accidents and serious accidents, occurred in the organisation 3. All the employees feel comfortable enough to inform the unusual events occurred in the organisation 4. Besides having performance indicators of safety at work, the company has indicators of performance in the environmental area

Table 6
Framework to identify maturity of safety culture in organisational learning (Translated to English).

Organisational learning				
Pathological	Reactive	Bureaucratic	Proactive	Sustainable
1. The organisation does not analyse any unusual events 2. The analysis of unusual events aims to identify the guilty ones only 3. The organisation does not propose any improving actions for safety at work 4. The organisation does not inform the analyses results of unusual events to its employees	1. Only the serious accidents are reported by the employees 2. There is a formal system which allows the employees to inform only the serious accidents occurred in the organisation 3. The employees do not inform any unusual events occurred because they do not feel comfortable enough in relation to the organisation 4. The only performance indicators of safety at work are the serious accidents occurred in the workplace	1. Most of the unusual events which occur in the organisation are not reported by the employees 2. There is a formal system that allows the employees to inform only the accidents, including the serious ones, occurred in the organisation 3. The minority of the employees feel comfortable enough to inform the unusual events occurred in the organisation 4. The only performance indicators of safety at work are the accidents and work-related illnesses rates	1. Most of the unusual events which occur in the organisation are reported by the employees 2. There is a formal system that allows the employees to inform all the unusual events, including accidents and serious accidents, occurred in the organisation 3. The majority of the employees feel comfortable enough to inform the unusual events occurred in the organisation 4. The organisation has other performance indicators of safety at work as well as the accidents and work-related illnesses rates	1. All the unusual events which occur in the organisation are reported by the employees 2. There is a formal system that allows the employees to inform all the unusual events, including accidents and serious accidents, occurred in the organisation 3. All the employees feel comfortable enough to inform the unusual events occurred in the organisation 4. Besides having performance indicators of safety at work, the company has indicators of performance in the environmental area

Table 7
Framework to identify maturity of safety culture in involvement (Translated to English).

Involvement				
Pathological	Reactive	Bureaucratic	Proactive	Sustainable
1. The employees do not engage in safety issues 2. The employees have no interest in participating in safety-related issues	1. The employees are invited to participate in safety-related issues only when serious accidents occur 2. The employees are interested in participating in safety-related issues only when serious accidents occur	1. The minority of the employees is engaged in safety-related issues 2. The minority of employees is interested in participating in safety-related issues	1. The majority of the employees are engaged in safety-related issues 2. The majority of employees are interested in participating in safety-related issues	1. All employees are engaged in both safety-related and environmental issues 2. All the employees are interested in participating in safety-related issues

Table 8
Framework to identify maturity of safety culture in communication (Translated to English).

Communication				
Pathological	Reactive	Bureaucratic	Proactive	Sustainable
1. The organisation does not communicate its employees any safety-related issues 2. There is not an open channel of communication between the organisation and its employees about safety-related issues 3. The organisation does not check if the communication about safety-related issues is effective	1. The organisation communicates its employees the safety-related issues only when serious accidents occur 2. There is an open channel of communication between the organisation and its employees only when serious accidents occur 3. The organisation checks if the communication about safety-related issues is effective only when serious accidents occur	1. The organisation communicates its employees the least part of the safety-related issue 2. There is an open channel of communication between the organisation and its employees; however, it is still incipient and bureaucratic and it is based on norms and procedure 3. The organisation checks if the communication about safety-related issues is effective only in areas where there are risks of accident and work-related illnesses	1. The organisation communicates its employees the most part of the safety-related issue 2. There is an open channel of communication between the organisation and its employees because the former considers safety-related issues relevant 3. The organisation checks if most part of the communication about safety-related issues is effective	1. The organisation communicates its employees all the safety-related issues 2. There is an open channel of communication between the organisation and its employees because the former considers safety-related issues relevant 3. The organisation checks if all the communication about safety-related issues is effective

Table 9
Framework to identify maturity of safety culture in commitment (Translated to English).

Commitment				
Pathological	Reactive	Bureaucratic	Proactive	Sustainable
1. Planning for safety at work is not done by the organisation 2. The organisation does not audit in safety at work 3. The organisation does not invest in safety at work 4. The organisation does not provide any safety at work training 5. The organisation does not have a team to give support in safety at work 6. The organisation considers safety at work only an expense 7. The procedures in safety at work are seen as limiting as far as activities are concerned 8. The organisation does not adopt a rewarding system to stimulate safety at work 9. The organisation hires outsourced companies for a lower price and shows no concern with safety at work in relation to them	1. Planning for safety at work is focused only on what went wrong in the past 2. The organisation audits in safety at work only after serious accidents and work-related illnesses occur 3. The organisation invests in safety at work only after serious accidents and work-related illnesses occur 4. The organisation provides resources so that specific training program in safety at work can take place only after serious accidents occur 5. The organisation has a small team to give support in safety at work 6. The organisation considers safety at work important only when serious accidents or work-related illnesses occur 7. The procedures in safety at work are written only in face of serious accidents that occur 8. The organisation adopts a rewarding system to stimulate safety at work only in specific situations, that is, after serious accidents and work-related illnesses occur 9. The organisation worries about safety at work in relation to outsourced employees only when serious accidents or work-related illnesses occur	1. Planning for safety at work is focused only on the identification and analysis of existing risks in the workplace 2. The organisation has an auditing program in safety at work only in areas where risk of accident and work-related illness exist 3. The organisation invests only to avoid risks of accident and work-related illnesses on the job 4. The organisation has standard safety at work training only for the employees who work in places where risks of accident and work-related illnesses exist 5. The organisation has a team that is big enough to give support in safety at work 6. The organisation considers safety at work important, but it emphasises production 7. The procedures in safety at work focus only the sectors where risks of accident and work-related illnesses exist 8. The organisation adopts a rewarding system for good performance in safety at work only for those sectors where risks of accident and work-related illnesses exist 9. The organisation has a pre-qualification process in safety at work before contracting outsourced companies. Nevertheless, there is no follow-up afterwards	1. Planning for safety at work is well structured with problem prevention and work procedures improvement, but It is not integrated with the other areas of the organisation 2. The organisation has an auditing program in all the its sectors for safety at work 3. The organisation invests systematically in safety at work in all its sectors 4. The organisation has a continuous training process in safety at work for all its employees 5. The organisation has a team that is big enough to give support in safety at work 6. The organisation seeks to prioritise safety at work, but it is not a reality yet 7. The procedures in safety at work are done the best way possible, but they are not periodically reviewed 8. The organisation adopts a rewarding system for all its sectors due to the employees' performance in safety at work 9. The organisation has a pre-qualification process in safety at work before contracting outsourced companies. Nevertheless, there is no follow-up afterwards	1. Planning for safety at work is well structured with problem prevention and work procedures improvement and It is integrated with the other areas of the organisation 2. The organisation has an auditing program in all its sectors for both safety at work and environment 3. The organisation continuously evaluates the need for new investment in both safety at work and the environment 4. The organisation has a continuous training process in safety at work for all its employees 5. The organisation does not have a team to give support in safety at work specifically because the responsibility for it is shared by all the organisation members 6. The organisation, in fact, prioritises safety at work and production equally 7. The procedures in safety at work are done the best way possible and are constantly reviewed for better effectiveness 8. The organisation considers its employees are highly motivated by both safety at work and the environment; therefore, it does not see the need for a rewarding system 9. The organisation considers the outsourced companies as part of its safety and environmental management system

includes the co-existing safety subcultures, differentiating according to the lines of plants in multi-nationals, hierarchical levels within an organisation, seniority, occupation, age, etc. (Cheyne et al., 1998; Mearns et al., 1998; Richter and Koch, 2004a,b).

Given the size and complexity of the organisations studied, within one specific organisation there are areas in which the maturity of safety culture is less well developed than in others. In large organisations there will be a large number of sub-organisations, each one with their own history, having a potentially distinct culture and run by managers with their own vision of where to go, and how. Moreover, safety culture will take time to get established, and developments may proceed more quickly in some areas than in others. Nevertheless almost all companies studied have been operating since 1978 and have achieved high levels of safety performance, but they have not achieved the highest stage of maturity of safety culture yet.

Although only safety managers answered the questionnaire and the interview, they described low stages of maturity of safety culture, such as pathological and reactive in their companies. Hudson and Willekes (2000) found more conservative evaluations of safety culture by managers than by operators and supervisors. They suggested that managers are better calibrated.

The reason why the multi-national and national petrochemical companies showed no significant differences regarding their stages of maturity could be due to the fact that the companies are based in the same integrated industrial complex and therefore may share practices or it could be due to the influence of a shared national culture with regard to perspectives on safety.

The safety culture maturity model measures the stage of maturity of safety culture of an organisation; however, it does not identify the influence of national culture on safety culture. If the safety culture maturity model is applied in one multi-national organisation in different countries with different cultures, it could identify the same stages of maturity in this organisation in different countries. This does not mean that there is no influence of national culture on safety culture or that there is no significant difference between national culture from different countries, but just that the companies reached the same stages of maturity of safety culture.

6.4. Limitations of this study

This study presents the following limitations. Twenty-three safety managers surveyed may represent a low sample number. Thus further research with a larger number of people, including employees, must be conducted. In addition, the environment where the framework was applied was homogeneous. In future studies it is important that a more heterogeneous cultural environment be used.

7. Conclusion

The maturity model concept is useful because it enables organisations to establish their current level of safety culture maturity and identifying the actions required to improve their culture.

The measurement framework developed is intended to provide an useful diagnostic tool for safety managers who need to be able to easily identify certain organisational characteristics. There is a lack of empirical research on these diagnostic tools for safety managers who need to be able to easily identify certain organisational characteristics. The presence of these characteristics could indicate the stage of safety culture maturity the company is at and if necessary, the strategies it can adopt to improve it. The model of Hudson (2001) and the framework were found to be practical, familiar and easy to identify levels of maturity of safety culture in the context of the Brazilian petrochemical industry.

Hudson's model and this revised framework may give both managers and researchers an overall assessment of safety culture in an organisation or a set of organisations when they do not have time and resources to study a large company or many companies simultaneously as the case of Camacari integrated industrial complex, because the framework can be easily applied by managers. Based on this framework, they will be able to choose the organisation and the study strategy to understand the safety culture in depth and to implement actions needed to improve it.

The possible application of the safety culture framework to other industries and countries should be done carefully. If the framework can be shown to make sense to organisations in other industries, its theoretical basis will be strengthened by the support for its ecological validity.

The framework needs also to be extended to employees; this will be the subject of future research to compare their responses with results obtained from safety managers.

Acknowledgements

The author would like to thank Rhona Flin, Kathryn Mearns and Evie Fioratou at the School of Psychology of University of Aberdeen for their valuable comments on an earlier draft of this article.

Appendix A

Tables 5–9 show the framework and how each one of five dimensions is treated in each one of the five stages of maturity of safety culture.

References

Cheyne, A., Cox, S., Oliver, A., Thomás, J.M., 1998. Modelling safety climate in the prediction of levels of safety activity. Work & Stress 12 (3), 255–271.
Choudhry, R.M., Fag, D., Mohamed, S., 2007. The nature of safety culture: a survey of the state-of-the-art. Safety Science 45, 903–1012.
Cooper, M.D., 1998. Improving Safety Culture: A Practical Guide. Wiley, London.
Cox, S.J., Cheyne, A.J.T., 2000. Assessing safety culture in offshore environments. Safety Science 34, 111–129.
Dane, F.C., 1990. Research Methods. Brooks/Cole, Pacific Grove, CA.
Davies, F., Spencer, R., Dooly, K., 2001. Summary Guide to Safety Climate Tools. Report 1999/063. Health and Safety Executive, Colegate, Norwich.
Dejoy, D.M., Schaffer, B.S., Wilson, M.G., Vandenberg, R.J., Butts, M.M., 2004. Creating safer workplaces: assessing the determinants and role of safety climate. Journal of Safety Research 35, 81–90.
Ek, A., Akselsson, R., Arvidsson, M., Johansson, C.R., 2007. Safety culture in Swedish air traffic control. Safety Science 45, 791–811.
Field, A., 2005. Statistics Using SPSS. SAGE, London.
Fleming, M., 2001. Safety Culture Maturity Model. Report 2000/049. Health and Safety Executive. Colegate, Norwich. <http://www.hse.gov.uk/research/otopdf/2000/oto00049.pdf>.
Flin, R., Mearns, K., O'Connor, P., Bryden, R., 2000. Measuring safety climate: identifying the common features. Safety Science 34, 177–192.
Garcia, A.M., Boix, P., Canosa, C., 2004. Why do workers behave unsafely at work? Determinants of safe work practices in industrial workers. Occupational and Environmental Medicine 61, 239–246.
Glendon, A., Stanton, N., 2000. Perspectives on safety culture. Safety Science 23, 193–214.
Gordon, R., Kirwan, B., Perrin, E., 2007. Measuring safety culture in a research and development centre: a comparison of two methods in the Air Traffic Management domain. Safety Science 45, 669–695.
Guldenmund, F., 2000. The nature of safety culture: a review of theory and research. Safety Science 34, 215–257.
Hahn, S.E., Murphy, L.R., 2007. A short scale for measuring safety climate. Safety Science. doi:10.1016/s.ssci.2007.06.002.
Hofstede, G., Hofstede, G.J., 2005. Cultures and Organizations: Software of the Mind, second ed. McGraw Hill, New York.
Hopkins, A., 2005. Safety, Culture and Risk. CCH, Sydney.
Hudson, P., 2001. Aviation safety culture. Safeskies 1, 23.
Hudson, P., 2003. Applying the lessons of high risk industries to health care. Quality & Safety in Health Care 12, I7–I12.
Hudson, P., 2007. Implementing a safety culture in a major multi-national. Safety Science 45, 697–722.
Hudson, P., Willekes, F.C., 2000. The hearts and minds project in an operating company: developing tools to measure cultural factors. In: Proceeding of the SPE International Conference on Health, Safety, and the Environment in Oil and

Gas Exploration and Production Stavanger, Norway. Richardson, Texas (SPE 61228).
Hudson, P., Parker, D., Lawton, R., Verschuur, W.L.G., Van der Graaf, G.C., Kalff, J., 2000. The hearts and minds project: creating intrinsic motivation for HSE. In: Proceeding of the SPE International Conference on Health, Safety, and the Environment in Oil and Gas Exploration and Production Stavanger, Norway. Richardson, Texas (SPE 61095).
IAEA, 1991. Safety culture. Safety Series No. 75-INSAG-4. International Atomic Energy Agency, Vienna.
IAEA, 2002a. Safety Culture in Nuclear Installations: Guidance for Use in the Enhancement of Safety Culture. International Atomic Energy Agency, Vienna.
IAEA, 2002b. Key Practical Issues in Strengthening Safety Culture (INSAG-15). A reported by International Nuclear Safety Advisory Group. International Atomic Energy Agency, Vienna.
Lawrie, M.J., Parker, D., Hudson, P.T.W., 2006. Investigating employee perceptions of a framework of safety culture maturity. Safety Science 44, 259–276.
Mearns, K., Yule, S., 2008. The role of national culture in determining safety performance: challenges for the global oil and gas industry. Safety Science. doi:10.1016/j.ssci.2008.01.009.
Mearns, K., Flin, R., Gordon, R., Fleming, M., 1998. Measuring safety climate on offshore installations. Work & Stress 12 (3), 234–254.
Mearns, K., Whitaker, S., Flin, R., 2001. Benchmarking safety climate in hazardous environments: a longitudinal, interorganizational approach. Risks Analysis 41 (4), 771–786.
Mearns, K., Whitaker, S., Flin, R., 2003. Safety climate, safety management practices and safety performance in offshore environments. Safety Science 41 (8), 641–680.
Neal, A., Griffin, M.A., Hart, P.M., 2000. The impact of organizational climate on safety climate and individual behaviour. Safety Science 34, 99–109.
Olive, C., O'Connor, T.M., Mannan, M.S., 2006. Relationship of safety culture and process safety. Journal of Hazardous of Materials 130, 133–140.
Parker, D., Lawrie, M., Hudson, P., 2006. A framework for understanding the development of organisational safety culture. Safety Science 44, 551–562.
Reason, J., 1997. Managing the Risks of Organisational Accidents. Ashgate, Aldershot.
Richter, A., Koch, C., 2004a. Integration, differentiation and ambiguity in safety cultures. Safety Science 42, 703–722.
Richter, A., Koch, C., 2004b. Letter to the editor. Safety Science 42, 979–983.
Rundmo, T., 2000. Safety climate, attitudes and risk perception in Norsk Hydro. Safety Science 34, 47–59.
Rundmo, T., Hale, A.R., 2003. Managers' attitudes towards safety and accident prevention. Safety Science 41, 557–574.
Schein, E.H., 2004a. Organizational Culture and Leadership. Jossey-Bass, San Francisco.
Schein, E.H., 2004b. Letter to the editor. Safety Science 42, 979–983.
Varonen, U., Mattila, M., 2000. The safety climate and its relationship to safety practices, safety of the work environment and occupational accidents in eight wood-processing companies. Accident Analysis & Prevention 32, 761–769.
Westrum, R., 1993. Cultures with requisite imagination. In: Wise, J.A., Hopkin, V.D., Stager, P. (Eds.), Verification and Validation of Complex Systems: Human Factors Issues. Springer-Verlag, New York.
Westrum, R., 2004. A typology of organisational cultures. Quality and Safety in Healthcare 13 (Suppl. II), ii22–ii27.
Williamson, A.M., Feyer, A.M., Cairns, D., Biancotti, D., 1997. The development of a measure of safety climate: the role of safety perceptions and attitudes. Safety Science 25, 17–27.
Zohar, D., 1980. Safety climate in industrial organizations: theoretical and applied implications. Journal of Applied Psychology 65 (1), 96–102.
Zohar, D., 2000. A group-level model of safety climate: testing the effect of group climate on microaccidents in manufacturing jobs. Journal of Applied Psychology 85, 587–596.