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Assessing safety culture in the Spanish nuclear industry through the use of working groups

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ABSTRACT

This paper presents the design and the implementation of a methodology for measuring and improving safety culture at a nuclear power plant (NPP). The study has involved the completion of a pilot project aimed at seeing how to make use of the RADAR logic (Results, Approach, Deployment, Assessment and Review) of the EFQM model as a tool for the self assessment of safety culture in a nuclear power plant. The work was aimed at finding evidence of the safety culture that was in place at the plant and at identifying both the strengths of that culture and any areas in which it could be improved. The score obtained from an analysis of those strengths and areas for improvement has made it possible to prioritise the actions to be taken. The identification of perceptions and evidence, the agreement on the strong points and areas for improvement and the quantification of the safety culture have been performed by groups comprising volunteers who work at the NPP. The advantages of this methodology are assessed in the paper.

1. Introduction

One of the most serious accidents occurred at Chernobyl in 1986. This event has been the subject of a great deal of investigation and has brought into being the concept of safety culture. Indeed, it has been written that "The Chernobyl accident can be said to have stemmed from deficient safety culture" (INSAG, 1988). The safety culture concept has its origins in the International Nuclear Safety Advisory Group (INSAG) (INSAG, 1986). As a result of the Chernobyl accident people began to detect and attach a great deal of importance to the critical role of human and organisational factors (Camino Lopez et al., 2008; Martorell et al., 1999; Medvedev, 1991; Meshkati, 2007; Misumi et al., 1999; Stanton, 1996).

The current attractiveness of safety culture is linked to the belief that the assessment of safety culture may provide leading indicators of the level of safety that exists in an organisation and may be used to benchmark organisational safety performance (Mengolini and Debarberis, 2007). It is generally accepted wisdom that an organisation that develops and maintains a strong safety culture becomes more effective at preventing individual and large scale accidents (Baram and Schoebel, 2007).

Currently there are numerous studies that link quality with safety, having demonstrated the close relationship between those concepts (Herrero et al., 2002; Mengolini and Debarberis, 2007) and the EFQM model is one of the best excellence models currently being applied. The idea thus arose that the assessment methodology of the EFQM model could be applied to measure safety culture in nuclear power plants.

The main objective of this study was the implementation of a methodology for measuring and improving safety culture at a nuclear power plant (NPP) using the EFQM model as a tool for the self assessment of the safety culture. The setting for this study is an operating nuclear power plant in Santa María de Garoña (SMG), in Burgos, Spain.

The next section summarises a review of previous literature on Safety Culture, what it means in the nuclear industry and how to measure it. The EFQM Excellence Model is presented in Section 3. Section 4 gives the methodology and how it has been implemented. The results are presented in Section 5, and finally, discussion and the conclusions are described in Sections 6 and 7.

2. Safety culture

There are two basic problems in assessing safety culture at an NPP. The first is to establish what is meant by the term safety culture and, specifically, what it means in the nuclear industry. The second problem is to determine how to measure it.

There is a great amount of interest in establishing a homogeneous worldwide definition of safety culture, but over the last

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few years this has not been achieved. It is acknowledged that there is no shared, validated approach on how to define, assess and measure safety culture and much remains to be learned and shared in this field (Mengolini and Debarberis, 2007).

Although the literature does not support any single definition of safety culture, it is probably reasonable to settle on a model that represents organisational culture as a particular application of the larger concept of culture, and then considers safety culture as a subset of organisational culture (Sorensen, 2002).

It is however necessary to distinguish between safety climate and safety culture. Climate refers to a "workforce's perceptions of the organisational atmosphere" (Flin et al., 2000). Climate is therefore more superficial and more transitory than culture. The essence of culture is defined by Schein (1992) as "a pattern of shared basic assumptions that the group learned as it solved its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think and feel in relation to those problems" (Schein, 1992). According to this distinction, safety culture is reserved to the basic assumptions of the organisation, in other words to "traits" that are stable and deep-rooted, while safety climate is used to address "states" of the organisation that are shallow, expressed within the context of and influenced by external and temporary circumstances. Safety culture in this sense becomes very difficult to measure directly but can be accessed for example through direct observations or interviews. On the other hand, safety climate, representing the overt manifestation of the organisation, is much easier to observe and record through surveys and questionnaires (Mengolini and Debarberis, 2007).

Since its formulation after the Chernobyl accident, the safety culture concept has been amplified beyond classic features of safety management, such as technical attention to hazards, the deployment of operational procedures, and regulatory compliance programmes, to incorporate principles of leadership and value-sharing, enhanced communications and organisational learning, and knowledge about the factors which shape individual and group behaviours (Baram and Schoebel, 2007).

Two examples of definitions of safety culture are as follows: "shared values and beliefs that interact with an organisation's structures and control systems to produce behavioural norms" (Uttal, 1983), and "the set of beliefs, norms, attitudes, roles, and social and technical practices that are concerned with minimising the exposure of employees, managers, customers and members of the public to conditions considered dangerous or injurious" (Turner et al., 1989).

The term safety culture is not used exclusively in the nuclear industry. Other industries have also demonstrated interest in the term, notably in the offshore, and shipping sectors, as a means of reducing the potential for large-scale disasters (Cooper, 2000). The safety culture concept has also been applied in air traffic control (Ek et al., 2007; Gill and Shergill, 2004). Recognising the importance of safety culture as a determinant of safety performance, the Centre for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers (AIChEs), has included "process safety culture" as an element in the new risk-based process safety (RBPS) model (Frank, 2007).

In the nuclear industry, the development of the concept of safety culture is discussed in a paper by Sorensen (Sorensen, 2002). Since the Chernobyl accident the concept has been developed in several documents of the IAEA (International Atomic Energy Agency, which reports to the UN), such as INSAG-3 "Basic Safety Principles for Nuclear Power Plants" (INSAG, 1988), INSAG-4 "Safety Culture" (INSAG, 1991) and others.

In these two documents (INSAG, 1988, 1991) and in the first document that was produced after the accident (INSAG, 1986), an evolution of the concept of safety culture can be seen. Initially it was understood to refer to the management and organisational factors as well as attitudes that are relevant to safety. INSAG, in document INSAG-3, explaining that "the phrase – Safety Culture – refers to a very general matter, the personal dedication and accountability of all the individuals engaged in any activity which has a bearing on the safety of nuclear power plants" (INSAG, 1988), but the meaning of the term was left open to interpretation, and guidance was lacking on how safety culture could be assessed.

It was not until the year 1991, in document INSAG-4, that the concept was explicitly defined by the International Atomic Energy Agency (IAEA) as: "that assembly of characteristics and attitudes in organisations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance".

This represents progress when compared with earlier definitions. It has to do with personal attitudes and habits of thought and with the style of organisations. Such matters are generally intangible; yet such qualities lead to tangible manifestations. This was the first time it was recognised that in order to evaluate safety culture, which is intangible, it is necessary to examine tangible facts. Thus, document (INSAG, 1991) proposes 143 questions aimed at assessing the effectiveness of a safety culture. These questions are divided into various groups, depending upon the kind of organisation that is to be evaluated: government and its organisations, operating organisations, research organisations and design organisations.

Until then, the fundamental problem with the INSAG approach was that it specified in great detail what should be included, while giving too little guidance on how to formulate an overall conclusion. The International Atomic Energy Agency (IAEA), in assessing and improving safety culture, has therefore produced the following documents, programmes and guidelines:

- TECDOC-860/1996. ASCOT Guidelines: Guidelines for Organisational Self-Assessment of Safety Culture for Reviews by the Assessment of Safety Culture in Organisations Team, summarising the concept of safety culture and describing a process for assessing it (IAEA, 1996). These guidelines restate and expand on the INSAG questions.
- TECDOC-1321/November 2002 "Self-assessment of safety culture in nuclear installations. Highlights and good practices" (IAEA, 2002b).
- TECDOC-1329/December 2002 "Safety culture in nuclear installations. Guidance for use in the enhancement of safety culture" (IAEA, 2002a).
- Guidelines for the SCART Mission (Safety Culture Assessment Review Team) (IAEA, 2005).

The IAEA has published a document presenting a theoretical model of safety culture. This establishes five characteristics (IAEA, 2006) to describe a strong safety culture, a trait that is regarded as desirable in a nuclear plant. These five characteristics are:

A. Safety is a clearly recognised value.
B. Accountability for safety is clear.
C. Safety is integrated into all the activities in the organisation.
D. Leadership for safety is clear.
E. Safety is learning driven.

In turn, each of these characteristics is supported by a series of *attributes*. These specify how the various aspects of each of these characteristics can be identified and given more detailed, concrete form.

The second problem we find ourselves facing is how to measure a safety culture. The way in which the safety culture of an organisation is evaluated is currently the subject of much debate (Prono-

vost and Sexton, 2005). The difficulty of measuring the safety culture concept is undeniable (Mengolini and Debarberis, 2007).

Surveys have been used as the tool for assessing the safety climate (Mearns et al., 2003). Investigations of safety culture have been carried out using safety climate questionnaires as the main instrument of measurement (Guldenmund, 2000). This is a rough and ready method, as Guldenmund suggests (Guldenmund, 2007). The questionnaires invite people to respond but have not in themselves been able to reveal the essential aspects of the safety culture of an organisation. They only reveal attitudes that are shared throughout the organisation.

Flin et al. (2000) carried out a review of surveys used to evaluate the safety climate in various industrial companies. The results of this study suggest that the most typically assessed dimensions relate to management (72% of studies), the safety system (67%), and risk (67%) (Flin et al., 2000). Studies have also been undertaken using surveys to assess safety culture in energy companies (Ostrom et al., 1993).

It has been said that the use of surveys for assessing and measuring safety culture, although important in many contexts, could be misleading unless additional activities are carried out to associate the responses to the questionnaires with the specific background, challenges and circumstances in which the surveys are undertaken (Carroll, 1998). Some investigators (Carroll, 1998; Mengolini and Debarberis, 2007) have considered it necessary to combine the use of surveys with that of other tools such as interviews and self-assessment workshops in order to delve deeper into the safety culture. Carroll, in his study, used a safety culture survey and group interviews. The survey was used to identify areas for further discussion and clarification through a series of individual and group interviews (Carroll, 1998).

Mengolini (Mengolini and Debarberis, 2007) argued that the results of general surveys and questionnaires can provide only very general information on the attitudes and feelings of personnel towards safety related issues. Furthermore, the results of the survey may represent the safety climate of the organisation, that is to say the "state" of the organisation in terms of its survival and future prospects. The responses may therefore be influenced and biased by external circumstances. It was therefore considered necessary to undertake a deeper investigation with a view to gaining a greater understanding of the values and meanings within the organisation. For this purpose, Mengolini and Debarberis used a self-assessment exercise. A safety culture enhancement programme was thus developed through the adaptation of the IAEA guidelines (IAEA-TECDOC-1321 "Self assessment of safety culture in nuclear installations" and IAEA-TECDOC-1329 "Safety culture in nuclear installations"). The methodology is based on questionnaires, interviews, field observations and self assessment.

Mengolini advises that it is necessary to collect the perceptions of workers in order to be able to evaluate the safety culture. The IAEA guidelines are very valuable as a starting point, but they have some limitations. Firstly, they provide a top down structured approach to safety culture, focused on formal management tools such as feedback systems, management commitment, and quality assurance and not on the point of view and experience of those who "act" in the organisation. Personnel should be allowed free access to those "actors" and to their perception of the organisation (Mengolini and Debarberis, 2007).

An example of the simultaneous application of various techniques is to be found in the assessment of the safety culture at the Davis-Besse Nuclear Power Station. In March of 2002, the First Energy Nuclear Operating Company (FENOC) discovered a significant degradation of the Davis-Besse Nuclear Power Station reactor pressure vessel head and entered an extended shutdown. An evaluation of the safety culture at the Davis-Besse Station was conducted during February 2003, using a methodology developed with the support of the US Nuclear Regulatory Commission (Haber et al., 2003). The methodology involved obtaining a variety of quantitative and qualitative information, using multiple data-gathering methods (functional analysis, structured interviews, behavioural anchored rating scales, behavioural checklists and an organisational and safety culture survey).

This shows that it is necessary to ascertain the perceptions of the workers in order to be able to assess the safety culture, not only through closed-ended questionnaires, but also through methods which permit a better understanding of the knowledge which the workers give and have of the safety culture of their company. It is necessary to develop a methodology which enables us to collect data that is not constrained or limited by the preconceptions of using a survey. It is however necessary to improve upon one of the weaknesses of the working groups (IAEA, 2002a) avoiding deviations when gathering the data on the way meetings are conducted, their content and their progress.

The objective of the methodology developed is to obtain a better understanding of the perceptions of the workers so that safety culture can be assessed. This approach uses working groups which work with pre-defined scripts to obtain wide ranging information, but without deviating significantly in the collection of information so that it will then be possible to process that information better.

3. EFQM Excellence Model

The European Foundation for Quality Management (EFQM) is a foundation located in Belgium. It was founded in 1988 by the leaders of 14 of Europe's largest companies, with the support of the European Commission. There are currently more than 600 member organisations, ranging from multinationals and major national companies to universities and research institutes. The foundation takes on a key role in increasing the efficacy and efficiency of European organisations, strengthening quality in every aspect of their activities and stimulating and providing assistance with the implementation of quality improvement.

What led to the creation of this powerful administrative network was the need to create a framework for quality improvement. The idea was to take the Malcolm Baldrige model in the United States and the Deming Prize in Japan and then adapt them to match European needs.

The EFQM Excellence Model (EFQM, 1999) was introduced in 1991 as the framework for the self-assessment of both public and private sector organisations (Ansoleaga, 2007; Westlund, 2001) and as the framework for judging the applicants for the EFQM Excellence Award. This award was presented for the first time in 1992 and has been presented every year since then. It is the most widely used model in Europe and has become the basis for the assessment of organisations for most national and regional quality prizes in the whole of Europe. The EFQM Excellence Model is the framework behind the award and it has clearly become the most commonly applied model in Europe for Total Quality Management (Westlund, 2001).

The EFQM Excellence Model is a non-prescriptive model, the basic element of which is self-assessment based on a detailed analysis of the operation of the management system of the organisation, using the criteria of the model as a guide. This does not go against other approaches (such as the application of certain management techniques, the ISO rules and specific industrial standards). Instead it brings all of these together in a wider, more complete management arrangement.

The regular, systematic use of the model by the management team will enable it to establish improvement plans that are based on objective facts and to achieve a common vision of the goals to be reached and the tools to be used. In other words, its application is based on:

1. The model being fully understood by all levels of management of the company.
2. An assessment of the situation in each area of the company.

The EFQM Excellence Model (EFQM, 2003), comprises nine elements grouped under five 'enabler' criteria (leadership, policy and strategy, people, partnerships and resources, and processes) and four 'result' criteria (customer results, people results, society results, and key performance results). The enablers represent how the organisation operates, and the results concentrate on the achievements with respect to organisational stakeholders, and how they can be measured and targeted (EFQM, 1999). Since 1999 the EFQM Excellence Model has been using the RADAR scoring matrix as its method of evaluation. RADAR stands for the following:

R *esults*: What the organisation achieves. In an excellent organisation, the results will show positive trends or a good sustained performance, the targets will be appropriate and they will be met, the performance will compare favourably with that of others and will have been achieved by the approaches. In addition, the scope of the results will cover all the relevant areas for the stakeholders.
A *pproach*: What the organisation intends to do and the reasons why. In an excellent organisation, the approach will be sound (with a clear rationale, well defined and developed processes, and with a clear focus on the stakeholders) and it will be integrated (supporting policy and strategy and linked to other approaches, as appropriate).
D *eployment*: What the organisation does to deploy the approach. In an excellent organisation, the approach will be implemented in the relevant areas, in a systematic manner.
A *ssessment and* **R** *eview*: What the organisation does to assess and review the approach and its deployment. In an excellent organisation, the approach and its deployment will be subject to regular measurement, learning activities will be undertaken and the results from both will be used to identify, prioritise, plan and implement improvements.

The logic of the RADAR Matrix coincides with the classic PDCA (PLAN-DO-CHECK-ACT), as shown in Fig. 1, often used in Quality Circles.

The RADAR scoring matrix is based on evidence being properly identified in advance within the organisation, which will make it possible to allocate scores to the three elements of the matrix: *Approach, Deployment, Assessment* and *Review*.

There are numerous studies which confirm the validity of the EFQM model for quality improvement and which regard the model as a valid representation of TQM (Bou-Llusar et al., 2009). The EFQM model is currently being used as the basis for new models aimed at improvement in areas other than quality, such as occupational hazard prevention and safety culture (Chinda and Mohamed, 2008; Nabitz et al., 2009).

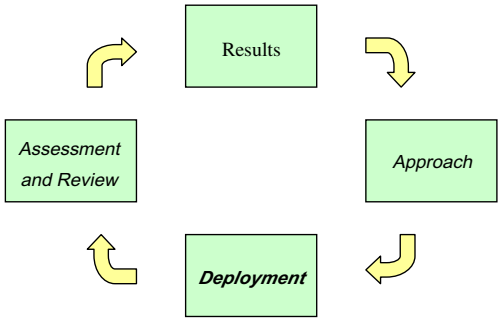

Fig. 1. RADAR logic.

4. Methodology

The project described below consists of designing a tool for the assessment of safety culture at the nuclear power plant by using concepts from the EFQM model such as the RADAR matrix and the use of working groups. The ultimate objective of the project is to measure the existing level of safety culture and to determine the strong points and the areas where improvement is required to raise that level. It is thus appropriate to adapt the EFQM Excellence Model as it is appropriately structured for the identification of the problematic situation, and includes the description of the present situation and the identification of deviations of the present situation from benchmarks (Rusjan, 2005).

Once the tool had been designed, the assessment was carried out using groups comprising volunteers who were workers at the company concerned. In addition, an attempt was made to identify areas on which to focus when undertaking actions at the plant to bring about a more profound safety culture.

The project carried out comprised various stages, as shown in Fig. 2. These were designed to achieve the following outcomes:

4.1. Involvement of the Nuclenor staff in the project/training.
4.2. Preparation of the questionnaires to gather evidence.
4.3. Seeking and identifying evidence in the organisation.
4.4. Identification of strengths and weaknesses.
4.5. Evaluation, using the RADAR scoring matrix.
4.6. Selection of subjects to concentrate on in order to bring about a better safety culture.

The tasks carried out in each stage, and the results obtained, are shown below.

4.1. Involvement of Nuclenor staff in the project

Using information posters, the company informed its staff that they would be able to join groups of workers who would be examining the concept of safety culture. Five groups of volunteers were set up. There were six people in each group, making a total of 30 participants. At that time the company employed 330 people on permanent contracts. This means that about 10% of the permanent staff decided to participate in the project. These volunteers were from various areas of the business (electrical maintenance, mechanical maintenance, radiological protection, administration, etc.) and from various levels of the hierarchy of the organisation (senior management, middle management, operators, etc.). Five facilitators were chosen to lead the groups and they were given training on self-assessment and safety culture.

The facilitators and all the other workers who took part in the project showed a great sense of involvement in the way they participated in the training sessions, the meetings to identify evidence, the meetings to reach consensus and, finally, the meetings to set out the results obtained.

4.2. Design of the evidence questionnaire

The safety culture was assessed using the five dimensions defined by the IAEA. These are internationally recognised as being necessary for a strong safety culture and as being desirable in a nuclear plant (IAEA, 2006). To have a better assessment it is necessary to have attributes for each dimension to assist in their evaluation. There are numerous studies on the best attributes for measuring safety culture (Alexander, 2004), and in our case we would use

the 28 attributes defined by UNESA (CEN-12, Rev 0, 2005). These 28 attributes are a summary of the 37 attributes defined by the IAEA in 2006 (IAEA, 2006). These dimensions and their attributes are shown on Table 1.

Additionally, to help us to evaluate each of the attributes and, following the philosophy introduced by the EFQM model, a questionnaire would be defined for each attribute. This would contain the points which have to be taken into account when exploring each attribute in greater depth. At this stage the questionnaire was produced. This was the document that was to be used as a guide at the meetings to seek out and identify evidence. It was the tool that facilitated the identification of evidence, in other words, of methods and activities relating to the safety culture.

The five characteristics of safety culture, with their attributes, were used as the basis for producing the questionnaire. The document has a total of 28 pages, one for each of the attributes of safety culture.

The areas to be assessed in each attribute constitute the main contents of the evidence questionnaire and show, by means of examples, good ways an organisation should act in terms of its safety culture. The questionnaires also include a blank section so that the evidence of the company itself, identified during the data

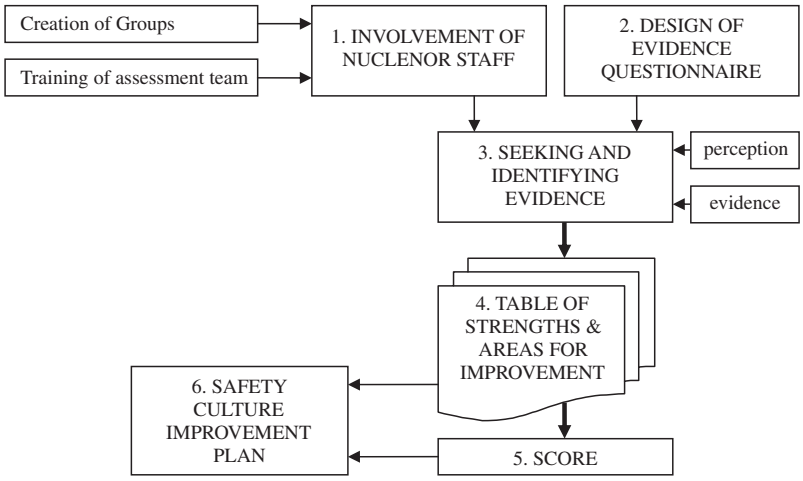

Fig. 2. Methodology.

Table 1
Attributes and dimensions of the safety culture.

Characteristics of safety culture	Attributes
Safety is a clearly recognised value	There is documentation that describes the importance and the role of safety in the operation of the organisation There is a decision making process that reflects the values and the priority of safety in an appropriate and specific manner Resources are allocated appropriately Behaviours that reflect safety awareness are supported and accepted at the company There are no conflicts between safety and production
Accountability for safety in the organisation is clear	Roles and responsibilities are clearly defined and understood The rules and procedures are adhered to There is an independent and constructive relationship with the regulatory authority Delegation of responsibility with the appropriate authority is permitted
Safety is integrated into all the activities in the organisation	Cooperation and team work is encouraged, supported and recognised Relations between managers and employees are established on a basis of openness and respect There is a communications program that is open and effective It is clear that the processes of organisational change are managed in an orderly fashion There is a good standard of housekeeping and good material and working conditions The quality of documentation and processes, from planning to implementation and review, is good Trends in performance indicators are recorded, assessed and established There is a profound knowledge and understanding of the work processes
Leadership for safety is clear	The management's commitment to safety is clear at all levels There is visible management leadership The involvement and motivation of all the staff of the organisation are obvious A conflict resolution process is in place and is used effectively There is a belief that safety can always be improved
Safety is learning driven in the organisation	The use of operational and organisational experience, both internal and external, is obvious There is a culture of reporting incidents that is open and without recrimination The use of self-assessments as an improvement tool is evident A process for detecting problems and for developing and implementing corrective action plans in an integrated manner is in place The continuous, professional and technical development of the staff is evident A questioning attitude exists throughout the organisation

EVIDENCE QUESTIONNAIRE	3.- SAFETY IS INTEGRATED INTO ALL ACTIVITIES IN THE ORGANIZATION How safety is just one more activity of the company
3.3.	THERE IS A COMMUNICATIONS PROG RAM THAT IS OPEN AND EFFECTIVE
In this "sub-division" (attribute) evidence of how the following is achieved will be sought: - A policy has been put in place for obtaining and using information through publications, sharing with other - Information on the socio-economic environment is obtained systematically. - The organization has efficient processes for providing information on its products and services, such as - The organization has internal channels for providing information and communicating that are both formal - The workers have access to the media. - There is an effective, two-way communication process that ensures the correct communication of safety - The good working and effectiveness of the communication system is assessed systematically. - All workers are informed of the hazards/risks found in their work posts on completion of risk and hazard	
EVIDENCE / PERCEPTIONS:	
1	evidence identified
2	evidence identified
3	evidence identified
4	evidence identified
5	evidence identified
6	evidence identified

Fig. 3. Evidence questionnaire on the attribute "there exists a communication programme that is open and effective", from characteristic 3 "Safety is integrated into all activities in the organisation".

collection process, can be recorded. Fig. 3 shows an example of this questionnaire for one of the attributes.

4.3. Seeking and identifying evidence in the organisation

The items of evidence were identified by the volunteer groups of workers from the Santa María de Garoña power station. The groups debated the attributes of the safety culture, using the questionnaires produced in the previous part. In the debates, the aim was to identify pieces of evidence by providing specific details that solidly supported that evidence. On occasions it was not possible to identify evidence, only perceptions.

Throughout the process of identifying items of evidence, the leaders reminded the meeting of the three elements of the RADAR matrix (approach, deployment, assessment and review) and directed it towards those elements so that the safety culture would be explored and assessed in greater depth.

Each of the five dimensions (or characteristics) of safety culture was assessed by two groups so that the greatest amount of evidence could be identified. Each of the groups undertook two sessions, each of these on a different characteristic. Each characteristic was analysed by two groups, and the data and evidence obtained by the two groups were brought together to make one single document for each characteristic.

4.4. Identification of strong points and areas for improvement. (SP's and AI's)

The group of five facilitators, together with staff from the University of Burgos, formed an analysis team. This team reviewed the joint evidence questionnaire in order to identify the strong points and the weak points. The identification of the points was carried out attribute by attribute. The process used was as follows:

a. Individual review of the evidence questionnaire.
b. Individual identification of the points.
c. Debate among the participants in order to arrive at a consensus.

In the course of the debate it was mentioned that some of the items described as evidence were really just "*perceptions*" as they were not based on actual specific data. The team therefore decided to talk of "*evidence and perceptions*".

4.5. Assessment using the RADAR scoring matrix

The analysis team evaluated each of the dimensions of the safety culture. The participants were told that it was important when allocating the scores to take into account the relevance to nuclear safety of the strong points and weak points identified in the previous section and the evidence found.

Having re-examined the meaning of and the method of allocating scores using the RADAR matrix (EFQM, 2003) each member of the team allocated his/her own score individually to the focus, the deployment and the assessment and review of each of the characteristics. The scores allocated were from zero to one hundred (see Fig. 4).

In the scoring process it is important to value the sound evidence and leave perceptions to await subsequent confirmation. To reach an agreed score allocation, the team acted in the same way as the evaluators of the EFQM model, as shown in Fig. 5. If the difference between the highest and lowest scores given was less than 25 points, the average of the scores given by the evaluators would be calculated. If the difference between the highest and lowest scores was greater than 25 points, the evaluators would hold a debate, putting forward their arguments in favour of their score allocations and discussing again the strong points and improvement areas, after which all the evaluators would individually give a new score for the dimension concerned, and this would continue until a consensus score was achieved.

4.6. Selection of areas on which to work in order to go into the safety culture in greater depth

Using the above information, the scores allocated to each dimension or characteristic, and the strong points and weak points of each characteristic, the team identified the areas to focus on in the company. A summary of this is provided in the following section.

5. Results

Using the above methodology and applying it to the Sta María de Garoña nuclear power plant, the strong points and areas for improvement for each attribute were obtained. Furthermore, in order to prioritise the actions to improve the safety culture, each dimension was allocated a score, item by item. This was done using the RADAR matrix. The scores given are shown in Fig. 6.

Elements		0%	25%	50%	75%	100%
Approach	**Sound** • approach has a clear rationale • approach has defined processes • approach focuses on stakeholder needs	No evidence or anecdotal	Some evidence	Evidence	Clear evidence	Comprehensive evidence
	Integrated • approach supports policy and strategy • approach is linked to other approaches as appropriate	No evidence or anecdotal	Some evidence	Evidence	Clear evidence	Comprehensive evidence
	Total	0 5 10	15 20 25 30 35	40 45 50 55 60	65 70 75 80 85	90 95 100

Elements		0%	25%	50%	75%	100%
Deployment	**Implemented** • approach is implemented	No evidence of implementation	Implemented in ¼ of relevant areas	Implemented in ½ of relevant areas	Implemented in ¾ of relevant areas	Implemented in all relevant areas
	Systematic • approach is deployed in a structured way with the method used for deployment being planned and executed soundly	No evidence or anecdotal	Some evidence	Evidence	Clear evidence	Comprehensive evidence
	Total	0 5 10	15 20 25 30 35	40 45 50 55 60	65 70 75 80 85	90 95 100

Elements		0%	25%	50%	75%	100%
Assessment & Review	**Measurement** • regular measurement of the effectiveness of the approach is carried out • regular measurement of the effectiveness of the deployment is carried out • measures selected are appropriate	No evidence or anecdotal	Some evidence	Evidence	Clear evidence	Comprehensive evidence
	Learning is used to: • identify best practice and improvement opportunities	No evidence or anecdotal	Some evidence	Evidence	Clear evidence	Comprehensive evidence
	Improvement Output from measurement and learning is analysed and used to: • identify, prioritise, plan and implement improvements	No evidence or anecdotal	Some evidence	Evidence	Clear evidence	Comprehensive evidence
	Total	0 5 10	15 20 25 30 35	40 45 50 55 60	65 70 75 80 85	90 95 100

Fig. 4. RADAR matrix, of facilitating agents.

It is important to emphasise that the scores given should not in themselves be considered important (just for the numbers themselves). The basic aim is really to have the various members of the team discuss the scores and seek consensus on the areas that are considered the most relevant to the nuclear safety culture. This went one step further than previous studies because by applying the EFQM model we had a way of evaluating the importance of each dimension, this being something which was not previously quantified (Haber et al., 2003).

The aim of the assessment is to identify areas on which to focus when establishing actions to help bring about improvement in the organisation.

The reasons for the scores given for each of the characteristics are given below. Emphasis is given to those areas which have caused points to be subtracted from the scores. These are areas on which it will be necessary to focus when bringing about a deeper safety culture within the organisation.

5.1. Characteristic no. 1: "safety is a clearly recognized value"

The overriding importance attached to nuclear safety is reflected in the mission, the vision and the values of the company. These are identified in the Integrated Management System (Grimston, 1997). Nuclear safety is also a value that is clearly recognised as the

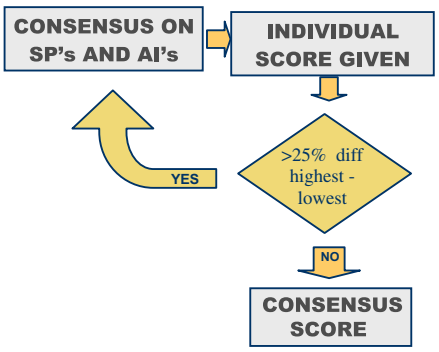

Fig. 5. Scoring process.

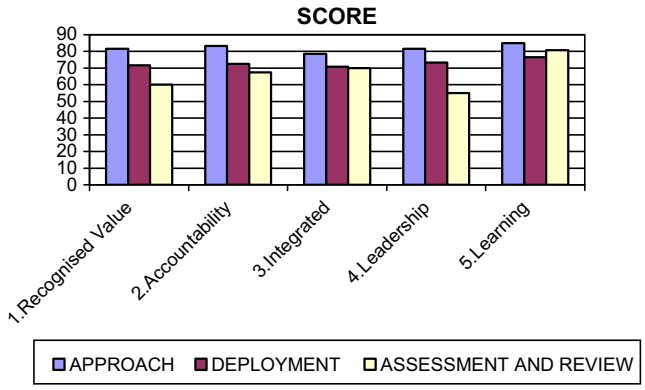

Fig. 6. Average scores allocated. *Source*: Produced by project team.

organisation's number one priority. In addition, the importance of nuclear safety is clearly evident in the day to day activities carried out, such as work orders, design modifications, tests, etc.

Nevertheless, the Integrated Management System has only recently been formalised and it was observed that its meaning has not yet been fully communicated throughout the organisation. It was also observed that there are no indicators that would provide a measurement of how clearly the value of safety is recognised. This could mean improvement opportunities being lost.

5.2. Characteristic no. 2: "accountability for safety in the organisation is clear"

Accountability with regard to nuclear safety related matters is clearly defined in the Operating Rules. The procedures associated with activities and processes that are nuclear safety related clearly define responsibilities at management and section level. High marks were awarded for the constructive relationship the organisation has with the Regulatory Authority (CSN), for the way the applicable rules and regulations are analysed, and for the culture of working with procedures. Another point that was seen as very positive was the extent to which documents are reviewed with a view to introducing any improvements that are detected through their use.

One area for improvement that was detected was the need to define more clearly the safety related roles in all work grades. It should however be mentioned that there is no refusal to accept responsibility for safety as occurs in other cases (Haber et al., 2003) and that only greater precision in the definition of responsibilities is lacking. Also detected was a perception of too much bureaucracy and paperwork that might on occasion conceal points that matter to nuclear safety to be vigilant of in the field. It is important to examine this point to determine to what extent it is true and thereby identify improvement opportunities.

5.3. Characteristic no. 3: "safety is integrated into all the activities in the organization"

The high degree to which nuclear safety considerations are taken into account in day to day activities was again highlighted. This concept is clearly integrated into the tasks/activities performed. In addition, consistent planning, deployment and assessment were also observed.

As older employees leave and are replaced by younger people, there is room for improvement in the mechanisms for transferring knowledge from experienced workers to younger staff. It would also be possible to achieve an improvement by putting in place mechanisms to increase the level of voluntary participation in working groups. There are also frequent process changes, affecting day to day activities, without the staff affected being well enough informed. This may cause uncertainty and affect performance.

5.4. Characteristic no. 4: "there is a leadership process with regard to safety within the organization"

The commitment of the Management to nuclear safety also won high marks. So too did the involvement of all the staff and their attitude of putting this matter above all else, and the fact that the entire staff was convinced that it is always possible to improve safety.

The workers are, in general, poorly informed of the activities carried out by the managers in the area of nuclear safety. This is due more to a lack of communication than to the management not actually carrying out these activities. It is therefore possible to improve the communication skills and resources of the management team. As occurs at other installations (Haber et al., 2003), there are problems with top down communication between the management and the staff or, if the information has been communicated, it has not been understood. Again, in this characteristic, staff was seen to be lacking in motivation to participate voluntarily in working groups.

An important point is the lack of assessment of systematic leadership in all levels of the organisation. This makes it impossible to identify improvement opportunities that would help to improve performance in this characteristic.

5.5. Characteristic no. 5: "safety is learning driven in the organization"

Within the "approach" part of this characteristic, high marks were awarded for the systematic training activities, the learning through operational experience and the systematic management of problems identified. There is also a clear culture of reporting incidents so that improvement actions can be put in place.

There is however a perception within the organisation that there is a work overload in certain sections. As this possible overload is not measured, it is not possible to determine the extent of the problem or its implications for nuclear safety. This means that improvement opportunities are being lost. Furthermore, contract staff are not involved in the reporting of problems and possible improvements which they identify in their daily work are not covered by the established system.

6. Discussion

Nuclear energy plays an important role within the international energy context. The safe, reliable operation of nuclear power plants is an absolutely essential requirement for them to remain in operation. The strengthening of safety culture will make it possible to meet this objective.

This strengthening of safety culture came about in the company under study and specifically in its workers throughout the safety culture self-assessment. Some aspects which indicate the involvement of personnel and its influence on safety culture are:

- Five people from the company performed the task of facilitator. They received training on safety culture, participated in group meetings to collect evidence and finally reached agreements on the evidence and the scoring.
- Thirty people from the company participated in the evidence collecting meetings.
- 332 Items of evidence were collected in the work meeting on safety culture.
- In each of the groups there were workers from different hierarchical levels of the company which made communication easier.
- Various meetings were held to show the results of the self-assessment to the workers, both those that had participated and those that had not. A written version of the results was also distributed.

With regard to the identification of the main areas for improvement when this methodology is applied to a nuclear power plant, various subjects arose from the assessment and the scores and it will now be possible to work on these in order to enhance the culture. Nevertheless, in order to focus efforts, three areas were selected for further action and the company is currently working on these three items:

- The development of leadership capabilities at all levels of the organisation.
- The establishment of indicators relating to the safety culture.
- The simplification of bureaucracy and paperwork.

In November 2007, Garoña received a SCART Mission (Safety Culture Assessment Review Team). This is an international review by a team of experts led by the International Atomic Energy Agency. The purpose of the SCART Mission is to identify strengths and areas for improvement that will help the company to progress and go into greater depth in aspects of its safety culture and learn of the most advanced international practices of implementation and enhancement of a safety culture.

In its report the SCART Mission highlighted the commitment of Garoña staff to improving the safety culture at the plant. It also mentioned the project for an internal assessment of the safety culture using the RADAR matrix, stating that it was a good practice. For the Mission, a good practice is a process that is in place and implemented, that is innovative and should be reported to all the other power plants throughout the world.

Since then, this same methodology has been used to carry out a self-assessment of the safety culture at another nuclear power plant in Spain (in 2008) (ASCO I and II) and in this exercise the use of the working groups was also successful. Additionally, towards the end of 2010 another safety culture self-assessment is being carried out at the Sta María de Garoña plant. The same methodology is being used in this new exercise so that the results obtained can be compared with those of 4 years ago, enabling us to determine the degree of implementation of the improvements proposed in that earlier study and the current status of the safety culture at that plant.

7. Conclusions

The results of this project demonstrate the validity of the RADAR matrix of the EFQM scoring model as a tool for assessing the characteristics of the safety culture of an organisation. With the design and use of this methodology, several objectives are met, these being:

1. Getting the staff involved in the assessment. The work provides a vehicle for discussion of safety culture amongst the participants.
2. The self-assessment of the safety culture by obtaining items of evidence, strong points and areas for improvement within each of the dimensions.
3. The obtaining of scores in each of the dimensions of safety culture.
4. The identification of the main areas in which the organisation can take actions aimed at strengthening its safety culture.

The work of the groups was one step in a process to improve safety culture by drawing people's attention to the subject, providing opportunities for people to talk about the relevant behaviours and generating more feedback and effective communications. The subjects identified in the project have made it possible for the company to plan future activities aimed at strengthening its safety culture.

The methodology for the self-assessment of safety culture which has been designed in this study uses a questionnaire to seek and identify evidence. The questionnaire developed is based on the 28 attributes of safety culture. The questionnaire would help obtain evidence to identify the strong points and areas for improvement in safety culture. These 28 pages, with the pieces of evidence identified, helped the people who carried out the self-assessment to debate various points relating to the attribute that was being analysed.

The RADAR matrix enables us to quantify each of the dimensions of safety culture. This quantification is made by taking into account the strong points and the areas for improvement identified in the evaluation process. The scores can be used as a point of reference for the future and provide a mechanism that helps prioritise the actions to be taken.

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