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Relationship of safety culture and process safety

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Abstract

Throughout history, humans have gathered in groups for social, religious, and industrial purposes. As the conglomeration of people interact, a set of underlying values, beliefs, and principles begins to develop that serve to guide behavior within the group. These "guidelines" are commonly referred to as the group culture. Modern-day organizations, including corporations, have developed their own unique cultures derived from the diversity of the organizational interests and the background of the employees. Safety culture, a sub-set of organizational culture, has been a major focus in recent years. This is especially true in the chemical industry due to the series of preventable, safety-related disasters that occurred in the late seventies and eighties. Some of the most notable disasters, during this time period, occurred at Bhopal, Flixborough, and Seveso. However, current events, like the September 11th terrorist attacks and the disintegration of the Columbia shuttle, have caused an assessment of safety culture in a variety of other organizations.

Keywords: DuPont; Safety climate; Safety culture

1. Safety culture versus safety climate

Safety culture can be viewed as the overarching policies and goals set by an organization relating to the overall safety of their facility or environment [7]. It is frequently referred to as "the way we do things around here." Safety climate is another buzzword often used interchangeably and in conjunction with safety culture. While both phrases can be used to describe the underlying safety attitude of an organization, safety climate generally refers to the attitude the people in the organization have towards safety. It describes the prevailing influences on safety behaviors and attitudes at a particular time. Culture can be viewed as the background influence on the organization, while climate is the foreground [1]. As a result, safety climate changes more quickly and more readily than safety culture. In the aftermath of a significant accident, it is the climate of an organization, rather than the culture, that will undergo immediate modification. However, if the underlying culture is not sufficiently and accordingly altered to support the climate, further incidents are inevitable. The primary example of such a phenomenon can be found in the duality of the Challenger and Columbia disasters experienced by NASA. Following the Challenger explosion, the climate at NASA was strongly oriented towards improving safety performance. However, because the underlying culture did not adequately promote the importance of placing safety as a priority, the safety climate degenerated to such a dangerous degree that the Columbia disaster resulted.

In retrospect, it is easy to see the deficiencies present in the culture at NASA between the incidents. There are several characteristics that identify a good safety culture and strong safety climate, and historically, these simply had not been integrated into NASA's culture. These characteristics include: a *commitment* to the improvement of safety behaviors and attitudes at all organizational levels; an organizational structure and atmosphere that promotes open and clear *communication* where people feel free from intimidation or retribution in raising issues, and are encouraged to ask questions; a propensity for *resilience and flexibility* to adapt effectively and safely to new situations; a prevailing attitude of constant *vigilance*. While it is difficult to physically measure these characteristics, it is certainly possible to observe them. The importance of each characteristic

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and its identifying features are discussed in detail in the following sections.

2. Characteristics of a good safety culture

2.1. Commitment

One of the primary characteristics of a good safety culture is a definable commitment to the improvement of safety behaviors and attitudes at all organizational levels. It is intuitive to assume that organizations dedicated to the improvement of their safety culture will begin to generate the additional features necessary to achieve a good safety culture. While it is imperative that each employee be committed to creating and maintaining a good safety culture, this commitment must begin in the boardroom.

The boardroom influences two aspects of safety. First of all, the Board should recognize that expenditures on safety provisions cannot be subject to the normal rigid financial review in terms of the rate of return on an investment [6]. Organizations with good safety culture will have constant or increasing budgetary allotments for safety issues like preventative maintenance, upgrades, and extra personnel. They will not allow safety matters to suffer in an attempt to maintain the bottom line.

The second influence of the boardroom stems from the fact that people, in general, do what management does, not what it says. If Board members and subsequent levels of management place high value on safety matters and safety considerations, then their sub-ordinates will do the same. The trickle down effect of safety awareness is vital to the creation of a good safety culture because "if people are not safety conscious, then no amount of gadgetry, fail safe devices and back up alarms can ensure safety" [6]. The value safety has to the organization will be reflected in how safety concerns rank in the company hierarchy. For instance, legal and environmental matters are often of such concern that many companies have a chief legal officer and vice-president of environmental affairs within their organizational structure. Therefore, organizations who value safety will have included in their Board members a safety committee chairperson, vice-president of safety affairs, or other officer of equivalent standing. Additionally, within each sub-ordinate level of the organization, there should be a safety coordinator or system in place [10]. Placing safety concerns in a prominent position demonstrates to employees that safety is a priority. By serving as examples in safety awareness, it will be easier for management to motivate their employees to strive for a safer work environment.

The truly committed organization dedicates resources to create an atmosphere in which employees desire to work safely by eradicating both ignorance of safety issues and apathy about following safety precautions. Doing so promotes the establishment of a good safety culture as employees begin to feel responsible for their own safety, and also for the safety of their peers [4]. This "want-to" attitude of safety compliance can be achieved with efficient training programs that teach, motivate, and sustain safety knowledge [3]. It is hard to generally quantify the most effective frequency of safety training, as requirements will vary from industry to industry as well as between levels of service. However, in an organization with the ideal safety culture, the overall goal of safety training and education programs should be to create a knowledge base within the employee and to promote the desire to expand it. Supervisors and managers who empower and encourage workers to take charge of their own compliance with safety regulations will help achieve this goal [10]. "By demonstrating a real concern for each employee, leadership helps establish a mutual respect, and the foundation is laid for a good effort" [3]. Most importantly, once the desire to work safely and to increase safety knowledge has been developed in employees, organizations must have readily available resources to fulfill this desire. They must provide adequate training and educational materials. These include the appropriate emergency procedures, regulation requirements, material safety data sheets, up-to-date process and equipment specifications, results of hazard analyses, and any other supplemental material necessary. If employees are unable to participate in training exercises or educational opportunities because of administrative constraints or lack of availability, their attitudes will change to reflect the seeming apathy of the management and the "want-to" safety environment will never be achieved.

Some organizations that have successfully developed good safety culture have demonstrated their commitment to safety by extending their focus beyond their facility borders. DuPont, in particular, believes that safety should be a part of every person's life. "Employees should not 'turn safety on' as they come to work and 'turn it off' when they go home" [3]. Also, in many cases, more workdays are lost due to off-the-job accidents than on-the-job accidents. As a result, DuPont encourages the development of off-the-job safety programs. For instance, the Swiss national railway system, SBB, wanted to reduce the number of workdays lost as part of an effort to improve their overall occupational safety record. After working with DuPont consultants, they launched a campaign to reduce off-the-job injuries through activities like subsidizing the purchase of cycling helmets and covering the costs for employees to have ski bindings professionally adjusted [3]. Programs such as these help employees internalize safety and subsequently improve the safety of the company [3].

An organization truly committed to improving their safety performance will avoid excessive focus on production rates or meeting schedules. An unbalanced focus on production or measurable events like product volume or incident occurrence will lead to the idea that safety and prevention are not important [9]. This type of environment will inadvertently promote the use of safety short cuts that may speed production, but ultimately endanger the employees. Focusing on production will also cause employees to favor the implementation of symptomatic solutions to technical problems. If a particular symptom has been successfully eliminated without

determining the fundamental problem, the pressure to permanently correct the fundamental problem tends to decrease [8]. For instance, installing additional supports on a pipe that has suddenly begun to vibrate will solve the problem to the pipe and may distract employees from determining what caused the vibrations to begin. This type of activity is dangerous because temporary solutions may become less effective over time or other symptoms of the same problem may arise to compromise the safety of the system as a whole [8]. Organizations guilty of placing overemphasis on results often utilize condition of employment policies and incentive systems that offer rewards for time worked without incidents [9]. These incentive systems generally encourage employees to hide or overlook incidents and endanger the safety of the facility.

2.2. Communication

A second characteristic of an organization with excellent safety culture is free and open communication. Ideally, an organization should have a structure and atmosphere such that its employees feel free from intimidation or retribution in raising issues, and in which they are encouraged to ask questions. It is vital to the safety of an organization that employees help minimize latent shortcomings of a system by challenging potentially unsafe practices and identifying deficiencies wherever and whenever they encounter them [5]. In addition, extensive communication between and among levels of the organization is necessary to maintain a good safety culture, as there exists a close interdependence between technical safety and organizational processes [11]. Without effective communication, these two elements may never be coordinated to appropriately handle safety issues as they arise.

Communication in an organization with good safety culture begins by informing all personnel of the intent of the safety program. This includes describing the ideal safety status, defining values that clarify how employees will work together, and establishing the process to achieve the desired results [9]. Information about the safety program should accompany information about particular risks and potential hazards to which each employee may be exposed to emphasize their individual contribution. It is imperative that employees and contractors have knowledge about why specific safety systems or requirements are in place and the importance of each item in contributing to safety if safety goals are to be reached [5]. Further, responsibilities must be clearly declared through formal assignment and description of duties [11]. By doing so, ambiguities about procedural details will have been eliminated. Employees will be able to determine exactly how safety systems and safety plans will operate. As a result, they will feel more confident in the program and its effectiveness.

A key indicator of a company with excellent communication between organizational levels is a “manage by walking around” (MBWA) philosophy. Quite simply, this philosophy dictates that managers should physically observe employees, procedures, and processes in their areas rather than remaining behind a desk. By actively engaging employees in discussions about their performance, managers develop a greater understanding of safety issues [9]. Additionally, face to face communication helps cultivate trust. This trust, coupled with an open door policy, helps ensure that a good reporting culture will develop. If employees feel strongly about an issue and need to convey its importance to higher authority, it is imperative to the safety of the facility that they feel comfortable doing so.

Communication should also extend beyond the facility borders. Surrounding communities, emergency response teams, and regulatory agencies need to be included in the communication network. Surrounding communities are generally home to an organization’s employees and emergency response personnel. It is therefore, crucial to the success of an organization that the communities accept their presence and do not feel endangered by them. This can only be achieved if the organization builds trust by providing sufficient information to the communities whenever it is needed [6]. Full disclosure to and cooperation with local planning authorities is imperative in the event of an emergency [6]. Because there was no such cooperation in Bhopal preceding the tragedy, confusion erupted in the surrounding streets and many additional lives were lost. Also, for safest possible installations, there must be close cooperation between government agencies, industry, and employee associations at the national level [6]. These entities will often be able to provide up-to-date information regarding new procedures or compliance techniques previously unavailable.

2.3. Resilience and flexibility

Resilience is another feature of a good safety culture. An organization with ideal safety culture should be able to easily process small incidents or errors within the system and then continue operating. By doing so, the organization and the system will ultimately become stronger. As such, resilient organizations may find it necessary to tolerate a certain level of errors, incidents, breakdowns, and accidents to protect certain systems against disaster [8]. As indicated in Fig. 1, as the overall number of incidents decrease, so does the situational awareness. The occurrence of another event will likewise raise the awareness level. If the awareness level is allowed to decline to such a degree that it is negligible by the elimination of incident stimulation, it is likely that severe consequences could result.

This postulate has been proven in the management of natural ecosystems. “The ability to learn from errors and to gain experience in coping with a wide variety of difficulty has proved a greater aid to preservation of species than efforts to create a narrow band of controlled conditions within which they would flourish but which leave the ecosystem vulnerable to more severe damage when things change” [2].

A resilient organization also strives to avoid reliance on redundancy. While the importance of secondary systems and system interlocks is not to be discounted, over-control may create a false sense of security and compromise coping ability

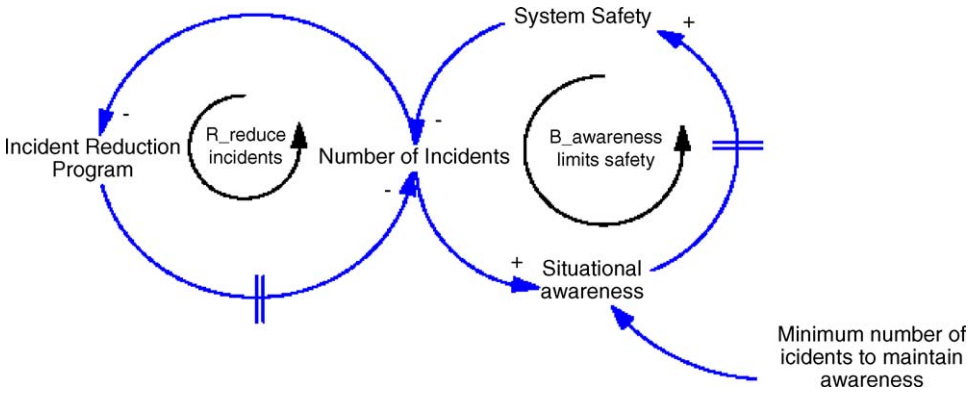

Fig. 1. Decreasing safety consciousness [8].

[2]. The assumption that a system is infallible could potentially lead to the inability to deal with even minor problems and the abandonment of ordinary precautions. This sort of situation could be called the "Titanic effect" as it was overconfidence in the ship's structure that caused the outfitters to stock far fewer life boats than could accommodate the ship's capacity and for the helmsman to use less caution while navigating. Also, "redundancy may 'cover up,' or mute design errors and prevent them from becoming visible until something catastrophic occurs" [8]. Marais and Leveson offer the following example of the dangers of redundancy.

"For example, an Air Force system included a relief valve to be opened by the operator to protect against overpressurization. A secondary valve was installed as backup in case the primary relief valve failed. The operator had to know when the primary valve had not opened in order to determine that the secondary valve had to be opened. One day, the operator issued a command to open the primary valve. The position indicator and open indicator lights both illuminated although the primary relief valve had not opened. The operator, thinking that the primary valve had opened, did not activate the secondary valve and an explosion occurred. A post-accident investigation discovered that the indicator light circuit was wired to indicate only the presence of power at the valve, and not the actual valve position. The indicator showed only that the activation button had been pushed, not that the valve had opened. Redundancy could not provide protection against the underlying design error. Worse, the overconfidence provided by the redundancy convinced the engineers that an examination of the wiring design was not needed and the design error was therefore not found."

Thus, by relying on the redundancy of the design the Air Force engineers prevented the system from becoming resilient by failing to examine the effectiveness of the secondary valve.

An additional feature of a resilient organization is flexibility and diversity in both operations and employee abilities. While there is no question that plainly outlined procedures for various production and maintenance activities are vital to the safe operation of a facility, flexibility within those parameters is equally as important. "Attempting to reduce risk by extinguishing variety may actually result in an increase in risk" [2]. For instance, allowing operators to use a variety of different, but accepted, techniques for a particular task may prove more beneficial to the completion of the task as future alterations to the process may render certain techniques obsolete.

Personnel flexibility can be the determining factor in the prevention of an accident. Naturally, all employees should have adequate skill and safety training for their work areas. However, it is important that employees are trained to be able to cover the duties of another employee should the need arise. This especially applies to key personnel like the safety officer and support staff. Should any of these key personnel become unavailable due to illness, vacation, or a recently vacated position, provisions should be in place to ensure that their responsibilities during an emergency or abnormal situation are covered. The Flixborough accident illustrates the significance that flexibility among employees has on facility safety. Just prior to the accident, the on-site Works Engineer had left. The services engineers were not instructed to seek outside assistance. They were told that a senior engineer from one of the holding companies (the Coal Board) was available for consultation when required. The services engineer did not think it necessary to consult him. They did not know that only an expert in piping design should design a large pipe operating at high pressure and temperature, so they designed it, and its supports, themselves. The services engineer did not know what they did not know (that is, the limitations of their own knowledge). The uninformed decision that was made resulted in the rupture of the bypass assembly and accompanying explosion. This catastrophe may have been avoided if the company ensured that someone remained on-staff capable of handling such a situation.

2.4. Vigilance

The final characteristic of an organization with an excellent safety culture is a prevailing attitude of vigilance.

Preparedness for and prevention of accidents must be maintained with constant unremitting watch [6]. Organizations with a history of safe operation often become complacent about adhering to safety measures [8]. However, it is when an accident is least expected that it is likely to occur. The terrorist attacks on September 11, 2001, are a prime example of tragedy striking a complacent safety culture. Airport security was operating at minimal levels believing extra caution unwarranted as no internal airborne threats to the nation had ever been postulated. As a result, the terrorists were allowed to board the planes and ultimately cause the deaths of many Americans. In order to avoid situations like this, it is necessary to prevent complacency by continuously monitoring risk.

While vigilant attitudes are apparent in all organizational levels in a good safety culture, vigilance must first begin with management. If managers engage in inadequate monitoring and follow-up of procedures, or only focus on safety measures in the aftermath of an accident, employees will begin to believe that safety is not important [9]. Also, employees will have no motivation to follow proper procedures if unsafe behaviors are not corrected or punished regularly. This will cause the safety of the environment to begin to degenerate. It is imperative that managers have the discipline to be constantly aware of the activities of their employees and to correct actions as needed.

Vigilant management will ultimately lead to vigilant employees. Employee vigilance in adhering to safety precautions is one of the most important ingredients in accident prevention. Because non-management employees deal with potentially dangerous situations in a hands-on capacity, they are the first line of defense. Vigilance on their part is two-fold. First, all employees must be diligent about reporting unsafe conditions or anomalies that may encounter. In a good reporting culture, it is accepted that the failure to report any issue may adversely and unacceptably affect safety [5]. Again, employees are the first to know if something has gone awry and it is imperative that they feel it necessary to take steps to correct the situation. Secondly, employees must be vigilant about adhering to safety protocols. This includes performing regular and rigorous maintenance of all equipment and systems, especially emergency equipment and systems [6]. Ensuring that remediation plans can be executed in the event of an emergency will allow for the speedy management of such a situation.

3. Steps to building a good safety culture

The importance of developing a strong safety culture can be attributed to the desire to minimize the occurrence of disasters. Using causal analysis to pinpoint a particular cause in the aftermath of a disaster like the inadequate reactor bypass at Flixborough or the foam strike preceding the Columbia launch can often skew the focus of an investigation away from determining ways to increase overall safety. This happens because the incident causes are studied and dissected to such a degree that they no longer seem random or unpredictable and thereby are deemed preventable [13]. Much effort is then spent trying to prevent that particular event from reoccurring. However, focusing on preventing the physical cause of one incident, in no way assures that another will not occur. Instead, assuring the development of a strong safety culture, capable of dealing with upsets or anomalies in which all employees hold safety as a priority will ultimately lead to the minimization of incidents.

For instance, as mentioned previously, there were many signs within NASA prior to the Columbia incident that indicated a strong safety culture was not present within the space shuttle program. Most notably was the lack of communication between the engineers concerned with the operational details of the shuttle and NASA senior management. There had been several previous occasions documented in which similar foam strikes had occurred during test launches. Yet, the magnitude of the potential danger was never communicated adequately to result in remediation. There were other physical defects to the shuttle with the potential to create disaster that were similarly ignored. As with the Challenger accident, the general attitude in these actions was, “it has not caused us a problem yet so we are not going to worry about it until it does.” If NASA had been diligent about creating a strong safety culture in which all potential risks are examined and minimized, it is possible that both of these tragedies could have been avoided.

Building a strong safety culture is an intensive procedure that requires the dedication of all members of the organization. Each level of the organization will have unique responsibilities and will find cooperation among levels to be vital. Specific steps that management and employees can take to help build a strong safety culture within their organization are outlined below.

3.1. Basic programs

Before the employees of an organization can commit to improving the safety culture, there must be certain base level programs in place to ensure that safety precautions and procedures can physically be carried out. These programs or systems can be viewed as common sense plans to maintain the physical safety of a facility. They will help to create the “picture” of the facility’s safety attitudes and will serve to reinforce the safety climate. The combination of these programs should help contribute to an overall physical prevention of and preparedness for emergencies.

One of the most obvious and necessary programs to have in place is a protocol for ensuring that storage volumes are kept as low as possible. While it is safer and more economical to keep storage volumes of any material low, this especially applies to flammable and reactive materials. Reducing quantities of hazardous substances in or around a process unit reduces the hazard level. It is also vital that proper containment devices are in place [6]. Designing process areas

to prevent the accumulation of flammable or toxic materials minimizes hazards resulting from spills or leaks. Although the necessity of policies regarding storage volumes may seem obvious, they are significant and should not be trivialized. In particular, stocks of intermediates should be reduced or, better, eliminated, as intermediates are usually very reactive, or they would not be used as intermediates, and therefore hazardous. Phosgene is an example.

Similarly, process areas should be designed and maintained to be as simple as possible. The basic idea is that less equipment causes fewer opportunities to fail. Designing equipment and controls in a linear, logical manner reduces the likelihood of mis-operation and enables the efficient handling of system upsets. Separating process steps and units from one another eliminates the possibility of the domino effect. The ability to easily isolate and control a small incident may prevent escalation to disaster.

Another important program to have in place is the regular and rigorous maintenance of systems and equipment [6]. Maintaining process equipment is necessary for the continuance of production, but also for assuring the safety of the process workers. Regular maintenance helps reduce the number of potentially dangerous malfunctions. This is especially true for emergency equipment and systems. It is vital that these apparatus be in full working order at all times. To complement the maintenance program, a work permit system should be strictly enforced covering work in all areas. There should be an appropriate system of documentation/authorization to ensure that competent people carry out the work to be done [6].

The importance of adequate training programs was discussed in the preceding commitment section. The company should feel that education and training should be ever-continuing [6]. Training programs are an integral part of the base level programs to help establish attitudes conducive to the development of a good safety culture. The programs should be provided by the company and should cover regular and emergency procedures as thoroughly as possible. In addition, the company should provide the relevant booklets and guides to help keep employees informed of all possible hazards and remedial activities [6]. In general, all those likely to be involved in an emergency or emergency response must be well versed in the specific hazards of the materials they are handling in order to deal effectively with the situation [6].

3.2. Management

The creation of good safety attitudes begins with management. It is the responsibility of managers to create an example in their own behaviors and attitudes towards safety. If managers buy into the organizational safety plan and promote the attainment of safety goals, their enthusiasm will begin to trickle down to their employees. There are several ways in which a manager's positive attitude toward safety can be expressed.

The first of these is to avoid the impulse to reward employees with good safety records. It would seem that rewarding good safety records would have a positive effect on safety much like rewarding students for good attendance positively affects overall school attendance. However, it can cause the intentional under-reporting of incidents [8]. Similarly, using punishment to achieve safety performance can be counterproductive. For this type of management to be effective, the punishments must be severe and frequent. In other words, the punishments must be harsh enough to dissuade recipients from repeating their mistakes and the recipient must feel that their mistake will not be overlooked, but in fact, punished. This type of system has several disadvantages. It is usually only useful in the presence of a manager. Employees are not likely to engage in safe behaviors if they are not being observed. Motivating employees through fear also damages personal relationships and suppresses involvement in teamwork [8]. Instead, managers should strive to minimize blame and to motivate employees by demonstrating the relevance and necessity of the safety precautions. By doing so, managers will help increase employee awareness of their own actions as related to safety procedures and improve the overall safety record of the area.

Managers who ascribe to the "manage by walking around" philosophy will find it easier to encourage incident reporting as face-to-face communication builds trust [5]. Also, managers develop a greater understanding of safety issues by actively engaging employees in discussions about their performance [9]. This practice can be supplemented by an informal audit process. For instance, DuPont uses layer audits with the anonymous documentation of unsafe acts. The auditor approaches the employee and helps them identify and correct unsafe actions [9]. The audit process helps employees to eliminate unsafe behaviors and aids management in identifying common problem areas. Another useful management tool facilitated by the MBWA philosophy is the use of safety report cards for each area or unit. This is a concept currently in use by Dow. The Dow report cards carry both criticism and praise of safety issues [6]. The cards help maintain a running record of the progress of the area and help provide a basis from which goals can be set.

Managers should also be aware of the capabilities of their employees. To begin, responsibilities must be declared through formal assignment and description of duties. Management must be sure that personnel understand all aspects of their responsibilities [11]. Because a certain amount of ambiguity exists with many safety precautions, it is imperative that managers outline as clearly as possible which employees are responsible for performing specific actions. This will help eliminate some of the chaos that tends to erupt during an emergency and enable more effective control of the situation. Similarly, managers must maintain a sense of reality about what can be achieved and on what timescales [5]. This issue ties into earlier discussions regarding the avoidance of a focus on production described in the commitment section. If employees are allowed sufficient time to complete their

tasks, it is likely that they will perform them without potentially dangerous shortcuts.

3.3. Employees

The non-managerial personnel of the facility have the bulk of the physical requirements in building a safety culture. It is these employees who must attend the training sessions, learn the safety requirements, and keep abreast of information regarding process hazards. Their attitudes will determine the safety climate of any facility. It is vital that these employees commit to and support the safety goals of an organization. Like the managerial staff, there are few actions the non-managerial personnel can take to help develop the characteristics of a good safety culture.

One of the most important activities that employees can engage in is peer observation and feedback [4]. This is regularly practiced in highly hazardous industries like nuclear power production and is often referred to as "safety coaching." Safety coaching includes constructive criticism of jobs performed, suggestions made for improvement, and general cooperation among employees to increase safety awareness and compliance. This practice has proved successful, as it is often easier to productively process criticism from a peer rather than a supervisor. Safety coaching also helps to ensure that less experienced employees will learn and follow the safety procedures properly.

Employees should also attempt to achieve a conservative approach to safety. In other words, a "better safe than sorry" attitude should be prevalent. This attitude can be manifested in the attention that employees give to the safety aspects of any job to be undertaken. Companies like DuPont have implemented moment of safety programs in which all safety issues must be discussed and considered before any work is initiated [9]. These types of programs help uphold vigilant attention to safety issues necessary in a good safety culture.

For a variety of reasons, when production problems occur, employees (unfortunately includes graduate engineers and not just mechanics) often find it easier to fix the symptoms of a problem rather than the root cause. It is vital that this practice be avoided. Correcting or preventing one symptom of a problem does no more to solve the problem than ignoring it all together. Other symptoms, perhaps more severe, will continue to surface until the underlying problem is dealt with appropriately. This practice could inadvertently cause a large-scale malfunction and compromise the safety of the facility.

4. Conclusions

Because the development of a strong safety culture has become so strongly desired in contemporary society, the question has been raised whether it is possible to regulate safety culture through industrial standards or governmental legislation. For the most part, the characteristics outlined above must be developed through the hard work and dedication of employees as an organization evolves. However, it could be possible to legislate certain features to help guide organizations in the right direction. An example of possible legislation could be the requirement that organizations provide outlined general programs for the management and implementation of safety plans prior to becoming incorporated. These outlines would be subject to review before incorporation is granted by the state. Most states require provisions for the regulation of internal affairs of the corporation [12]. Safety provisions could simply be a sub-set of this requirement. Another possible regulation could be the requirement that any organization with a specified number of employees document the distribution and receipt of the safety plan outlining the safety attitude and goals of the company to each employee. Thus, the company and regulatory body could ensure that all employees were aware of safety policies. Undoubtedly, there are other examples of administrative policies to help build good safety culture.

Possible regulations aside, the development of a strong safety culture in any organization is both necessary and achievable. A strong safety culture is characterized by several traits: a definite *commitment* to the improvement of safety behaviors and attitudes at all organizational levels; an organizational structure and atmosphere that promotes open and clear *communication* in which people feel free from intimidation or retribution in raising issues; a propensity for *resilience and flexibility* to adapt effectively and safely to new situations; a prevailing attitude of constant *vigilance*. Organizations that embody these characteristics and strive to make safety awareness a priority for all their employees will create the foundation upon which good safety culture can grow. Once employees incorporate the organizational attitude into their own outlook on safety and reflect that attitude in their actions, the safety culture will begin to take shape. It is the cooperation between these two entities, the organization and its employees that will ultimately create the strong safety culture imperative to the safety of the organization and ultimately, the overall safety of society.

References

[1] Behavioral Science Technology, Inc., Assessment and Plan for Organizational Culture Change at NASA, www.nasa.gov (07/12/2004).
[2] M. Douglas, A. Wildavsky, Risk and Culture, University of California Press, Berkeley, CA, 1982.
[3] Dupont Safety Resources, The DuPont Safety Philosophy, www.dupont.com/safety/en/aboutus/safety-philosophy.shtml (07/12/2004), Safety Solutions, www.dupont.com/safety/en/aboutus/results-swiss.shtml (07/12/2004).
[4] C. Johnson, The Principles of a Total Safety Culture, Idaho National Environmental Engineering Laboratory, Department of Energy, 2004, http://tis.eh.doe.gov/vpp/articles/idaho_safety_culture.html (06/03/2004).
[5] Key Practical Issues in Strengthening Safety Culture, INSAG-15 International Nuclear Safety Advisory Group, International Atomic Energy Agency, Vienna, Austria, 2002.

[6] O.P. Kharbanda, E.A. Stallworthy, Safety in the Chemical Industry: Lessons from Major Disasters, Heinemann Professional Publishing, Oxford, UK, 1988.
[7] Loughborough University, Safety Climate Measurement: User Guide and Toolkit, http://www.lboro.ac.uk/departments/bs/safety/document.pdf.
[8] K. Marais, N.G. Leveson, Archetypes for Organizational Safety, MIT Department of Aeronautics and Astronautics, Cambridge, MA, USA, 2003, http://shemesh.larc.nasa.gov/iria03/p01-marais.pdf.
[9] T.E. McSween, The Values-Based Safety Process: Improving your Safety Culture with Behavior-Based Safety, second ed., John Wiley and Sons, Hoboken, NJ, 2003.
[10] A.D. ShamRao, Shaping a Safety Culture, Divaker Ltd., 2004, www.divaker.com/resources (6/3/2004).
[11] Safety Culture, http://www.npp.hu/biztonsag/Kulture-e.html (06/03/2004).
[12] SBA: Online Women's Business Center, What are Common Incorporation Requirements?, www.onlinewbc.gov/docs/finance/incorporation_requirements.html (07/28/2004).
[13] N.N. Taleb, Learning to Expect the Unexpected, Op-Ed Article, The New York Times, New York, April 2004.