# Safety Culture Metrics and Assessment Factors


## Abstract

Past approaches for assessing safety culture health at nuclear plants have proved ambiguous at best and misleading at worst. This paper outlines some of the current nuclear industry guidance for safety culture assessments and proposes a transition to some metrics that may be more firmly rooted in organizational culture theory. The hope is that this information will prove useful for ORSIM development.


## Background

It has been said that safety culture affects everything at a site, which is how safety culture assessment has typically been approached – by looking at anything and everything that might be associated with safety culture.

At one point INSAG identified some 300 items. This led to the application at many plant sites (including Millstone in the mid 1990's) of extensive culture surveys. Impressive amounts of data were collected, but the heath of the culture remained difficult to discern. Ultimately, none of the various survey methods or NRC / INPO inspection methods proved clear, reliable indicators.

As former NRC chairman Dr. Richard Meserve said in his speech at the 2002 INPO CEO conference:

> "The concept of safety culture has core ingredients on which perhaps all can agree, but the precise limits of this somewhat amorphous concept are hard to discern. Moreover, given that the concept is not crisply defined, it is not surprising that neither the NRC nor other organizations have found an unambiguous way to measure it.

The major problems with not defining safety culture "crisply" (to use the words of Chairman Meserve) are: 1) it makes unambiguous, objective measurement impossible and 2) it opens the door for the application of metrics that may be incidental to the health of the culture - metrics that may be influenced more heavily by other factors other than culture, metrics that may be neither the direct determinants nor the direct resultants of the culture.

## Long production runs

The NRC has long held that extended production runs are an indicator of a healthy safety culture. During a 2002 INPO CEO conference panel discussion Peter Burg, then Chairman and CEO of FirstEnergy, commented that Davis-Besse's strong performance masked signs of potential safety culture problems:

> *"Indications were that Davis-Besse was a strong performing plant. It surpassed its 1995 world record of a 99.2 percent capacity factor by reaching 99.7 percent in 2001…achieving a 500-day run in October of 2001…and achieved 5.5 million hours worked without a lost-time accident in 2001. Would this kind of performance have raised any red flags with you? It didn't with us."* The Nuclear Professional Fourth Quarter 2002, pg. 3.

Long production runs misled both the NRC and FENOC on the health of the Davis Besse culture. INPO Human Performance Fundamentals Course "Managing Human Performance" pg. 135 has this message on the subject:

> **Myth 1 – If there are no events, there is no human performance problem.**
> Facts: Trivial human errors occur moment by moment in a nuclear power plant. The absence of events is more a function of the presence and integrity of defenses, barriers, controls, and safeguards than the errors people make. Therefore, it is erroneous to believe human performance is adequate just because the plant has not experienced events in the recent past. Reducing the number of errors does influence the frequency of events. But, a major contributor to a station's recent long, event-free run may just be coincidence. Verification of defenses should be an ongoing task for management, one it should expect to be held accountable for.

Industrial safety

In 2001DB achieved 5.5 million hours without a lost-time accident. This also misled FENOC on the health of the nuclear safety culture. This illustrates there is a distict difference between a healthy industrial safety culture and a healthy nuclear safety. Many plants (maybe most plants) put much more focus and resources on managing industrial safety. INPO talks about the important of having respect for the core and recognizing nuclear as different. However, many plants don't have a clear concept of the different safety cultures on site, and manage as if they were all the same.

Organization culture / safety culture relationships


Materiel condition

Some people argue they can gauge safety culture by walking through a plant and observing the

materiel condition. According to Plant Manager Randy Fast, Davis Besse had the best materiel condition of any FENOC plant. The materiel condition of DB was not a good indicator of the health of the safety culture, and may have helped mask a degraded culture. Good materiel condition may indicate a plant with a strong attitude of continuous improvement, or may just indicate management with a priority on "spit and polish" but not necessarily culture management.

Operator error

According to Plant Manager Randy Fast, prior to the event Davis Besse operators had one of the lowest error rates in the industry. This may have contributed to a false perception that the safety culture was strong.

INPO Human Performance Fundamentals Course "Managing Human Performance" pg. 135

> **Myth 8 – Errors cause significant events.** Facts: Significance is a function of severity, and severity is a function of the robustness of defenses. Errors generally determine the frequency of events. Errors trigger events. However, several defenses generally must fail in addition to the error to suffer a significant event.

Although operators had low error rates, it was a lack of questioning attitude that contributed to the event. Every few days operators replaced containment air filters that previously did not require changeout for months. For more than a year operators observed boric acid plating out on containment surfaces and equipment but did not sufficiently question and follow up on the root cause.

Robustness of defenses

If one could nutshell the root cause of the Davis Besse event, it would be a "lack of robustness of defenses". The four levels of "defense in depth" are: worker, manager, internal oversight and external oversight. All four levels failed at Davis Besse prior to the acid hole event.

Level 1

1. At the worker level, the system engineer was aware he was not fully cleaning the reactor head in accordance with the boric acid control (BAC) procedure.
2. At the worker level, operators did not question the unusual frequency of containment air filter changes, and the unusual plating out of boric acid throughout containment.

Level 2

1. Management was aware that the configuration of the reactor head did not facilitate complete cleaning (there was CR written 10 years ago) but for many years accepted this condition.
2. When video of the boric acid deposits at the control rod drives was shown to the NRC by management, the NRC claims information was intentionally altered and hidden. A number of DB staff are now under investigation for providing false information to the NRC.

Level 3

The oversight group was aware the BAC procedure was not being properly and fully implemented, but did not push management for resolution of the issue. The FENOC root cause analysis report on the Davis Besse QA organization concluded (executive summary):

*It was determined that the root cause was that D-B's nuclear safety values, behaviors and expectations were such that oversight was not set apart, in terms of expectations and performance standards, from the balance of the station…and resulted in the station tolerating conditions that were potentially detrimental to safety for long periods of time.*

This conclusion struck me as odd - why should oversight's values and behaviors need to be set apart from the balance of the station, if the station has a healthy safety culture and a continuous improvement attitude? This conclusion comes across as if oversight believes the entire station does not require a healthy culture. Anyway, this illustrates the need to reinforce safety values and behaviors within organizations, if not entire stations.

Level 4

1. When the DB reactor head system engineer went to the NRC residents with evidence of abnormal boric acid deposits on the reactor, the residents did not follow up.
2. Although there was a "high probability" of CRD cracking, Davis Besse management asked NRC NRR to be allowed to operate until normal shutdown. The manager of NRR wanted to allow continued operation, and overruled the NRR staff that had voted for immediate shutdown.
3. Prior to the event, INPO identified leadership issues at Davis Besse but did not follow up and push FENOC leadership to address the issues.

Safety culture and leadership

All four defense in depth barriers failed at Davis Besse, some multiple times. Site safety culture management can do little about the fourth (the regulator) barrier. Culture management can improve the robustness of the other three.

How is this accomplished? What indicates that it has been accomplished successfully? The key is not to look at what safety culture acts upon (as anything here would be influenced by other factors) but to look at what acts upon safety culture. Considerable industry guidance tells us what acts primarily on safety culture are the actions of (what the INPO Human Performance Group refers to as) the SLT – the Site Leadership Team.

In a *quality* safety culture an attitude of excellence and continuous improvement is shared by all personnel operating and maintaining the high hazard venture, in our case nuclear power. Safety is everyone's responsibility, but instilling the safety attitude, making sure the attitude exists across the organization is a function of *leadership*, and is the responsibility of the SLT.

> *"Leaders create culture. If a culture becomes misaligned, it is ultimately up to the leadership to do something about it"* - Dr. Edgar Schein MIT

INPO Human Performance Fundamentals, Ch. 4 "Leadership"

*"Without leadership intervention, production practices will overcome those aimed toward*

*<u>prevention</u>. Production behaviors will take precedent over prevention behaviors unless there is a strong safety culture – the central role of leadership." Pg. 95*

Pg. 95 also has a table listing production and protection behaviors. Production behaviors are identified as requiring *management*, prevention (safety) behaviors are identified as requiring *leadership*.

behaviors are listed in the table below:

| Production Behaviors: | Prevention Behaviors: |
|---|---|
| • will *accomplish* the station's mission | • will *avoid* challenges to the mission |
| • will *achieve* desired results | • *will protect* desired results |
| • are *process* driven | • are *values* driven |
| • are *easy* to measure | • are *hard* to measure |
| • are frequently *reinforcing* | • are perceived as *burdensome* |
| • provide natural feedback | • provide little or no feedback |
| • can be perceived as *mandatory* | • can be perceived as *optional* |
| • involve the *mind* (logic) | • involve the *heart* (emotion) |
| • require ***management*** practices | • require ***leadership*** practices |

INPO identifies in the table that prevention behaviors are "hard to measure" and "provide little or no feedback". This says something about the perception held by many in the nuclear industry that safety culture is <u>difficult or impossible</u> to assess effectively and reliably.

<u>INPO Human Performance Fundamentals, Ch. 6 "Managing Human Performance"</u>

Safety culture is but one component of human performance. The NRC, IAEA and INSAG often treat them as interchangeable, but there is a lot more to human performance than safety culture.

The formula in chapter 6 (pg. 132) helps to make the distinction and clarify the relationship:

From pg. 132

<u>Reducing the Frequency and Severity of Events</u>

Reducing active errors (Re) and managing defenses (Md) will lead to no significant events (ØE).

$$\boldsymbol{Re + Md = ØE}$$

Human performance focuses on both *reducing errors* and *managing defenses* to create immunity to significant events. Safety culture deals primarily with the *managing defenses* part of the formula (specifically the *cultural/leadership* areas).

From pgs. 133 / 134

Managing Defenses

Defenses are established through

a) engineered controls that optimize equipment condition and the human-machine interface,

b) various administrative controls such as procedures and training,

c) cultural controls that address the values, attitudes, beliefs, and habits of the workforce

d) management and oversight controls that promote accountability for managing defenses.

Leadership Practices

Leadership is a defense. Leaders possess passion for the vision of preventing plant events and the errors that cause them. Quality coaching, reinforcing, and counseling will promote a clear vision of safety's part in plant performance, and values, attitudes, and beliefs that encourage safety. A robust safety culture requires aggressive leadership emphasizing healthy relationships that promote open communication, trust, teamwork, and continuous improvement.

In general, leaders practice the following behaviors:

- Facilitate open communication.
- Promote teamwork to eliminate error-likely situations and strengthen defenses.
- Search for and eliminate organizational weaknesses that promote error and degrade defenses.
- Reinforce desired jobsite behaviors.
- Value the prevention of errors.

INSAG on safety culture management

INSAG 15 identifies three levels of plant safety culture from least to most evolved. In level one safety is viewed only as compliance to rules and regulations. In level two safety is managed as targets and goals. In the most advanced (level three) safety is viewed as a continuing process of improvement to which everyone contributes.

A "quality safety culture" is what INSAG defines as a level three culture:

- the SLT understands and faithfully implements it's role in safety culture management
- there is a learning organization in place
- safety principles are regularly reinforced
- problems are used as opportunities for learning and improvement, not to place blame
- the worker/manager relationship has been developed such that workers are unafraid

to raise issues and are actively encouraged to identify quality improvements.

INSAG 15 includes an appendix titled “Questions for Assessing Personal Contributors to the Enhancement of Safety Culture”. It lists many behaviors SLT members should keep in mind when managing safety culture, but is not developed enough or selective enough to be of much use for ORSIM factors.

IAEA “Self Assessment of Safety Culture in Nuclear Installations” document

Chapters 3 and 6 of this document provide a number of safety culture assessment elements. Chapter 3 identifies organizational factors by relative importance, specifically identifying *continuous improvement attitude* and *management commitment* as dominant factors. Additionally, chapter 6 identifies over 20 sub-elements that IAEA says indicate a weak culture.

3.2. RELATIVE IMPORTANCE OF ORGANIZATIONAL FACTORS

Whilst all the organizational factors are important, the subgroup discussing this topic took the view that some factors were of greater relative importance. The various organizational factors discussed in the previous section were rated on a scale of 1 to 10, with 10 representing what the subgroup regarded as the most important.

Organizational factor Rating

Continuous improvement attitude 10
Management commitment 9
Resource adequacy 5
Effective communications channels 4
Effective planning system 3
Skills and competencies 3
External influences 1

6. SYMPTOMS OF A WEAKENING SAFETY CULTURE

6.1. Importance of detecting symptoms
6.2. Utility perspective
6.2.1. Lack of systematic approach
6.2.2. Procedures not properly serviced
6.2.3. Incidents not analysed in depth and lessons not learned
6.2.4. Resource mismatch
6.2.5. Violations increasing in number
6.2.6. Increasing backlog of corrective actions
6.2.7. Insufficient verification of readiness for operation or maintenance
6.2.8. Employee safety concerns not dealt with promptly
6.2.9. Disproportionate focus on technical issues
6.2.10. Lack of near miss reporting
6.2.11. Lack of self-assessment processes
6.2.12. Housekeeping
6.3. Regulator perspective
6.3.1. Failure of corporate memory
6.3.2. Low status of Quality Assurance Department
6.3.4. Lack of ownership

6.3.5. Isolationism
6.3.6. Lack of learning
6.3.7. Unwillingness to share or co-operate
6.3.8. Failure to deal with the findings of independent external safety reviews
6.3.9. Deficiencies in regulatory bodies

**Note: It is tempting to simply plug the above "symptoms" into an ORSIM model, but this would be the wrong approach.**

With the "plug-in" approach, one could argue since Davis Besse had long production runs, low operator error rates, good housekeeping, low number of complaints to the NRC, that DB had a strong safety culture, which is what the NRC believed prior to the event. This conclusion would be incorrect. One can cherry-pick from the above factors to make any culture appear healthy.

Individually, the above factors point out areas of poor human performance. Collectively, these factors probably indicate weak management, but they do not reliably indicate the health of the safety culture.

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## The NRC Reactor Oversight Process' Safety Culture Approach

Safety culture includes the following 13 components:

1. Decision-Making
2. Resources
3. Work Control
4. Work Practices
5. Corrective Action Program
6. Operating Experience
7. Self- and Independent Assessments
8. Environment for Raising Nuclear Safety Concerns
9. Preventing, Detecting, and Mitigating Perceptions of Retaliation
10. Accountability
11. Continuous Learning Environment
12. Organizational Change Management
13. Safety Policies

The above is a preliminary NRC method for improving the safety culture inspection process, the process that was unable to flag culture problems at Davis Besse prior to the SOE. Most of the components listed are general HU functional areas, and are acted upon by many factors other than safety culture. Using these factors it is unlikely the NRC will be able to reliably assess the health of a plant safety culture.

Unfortunately, the NRC still endorses and subscribes to the old INSAG definition that Dr. Meserve indicated was a barrier to effective and unambiguous culture assessment:

> *"That assembly of characteristics and attitudes in organizations and individuals which establishes that, as an overriding priority, nuclear plant safety issues receive the attention warranted by their significance."*

Unless the NRC develops and endorses a clearer, more appropriate definition, according to the Theory of Quality Management (define-measure-manage) the NRC has little chance of developing effective and accurate inspection methods.

INPO Principles for a Strong Nuclear Safety Culture

INPO has improved on the old INSAG definition, developing a definition that identifies values and behaviors as components, and points out that culture is modeled by leaders.

> *Safety culture: An organization's values and behaviors—modeled by its leaders and internalized by its members—that serve to make nuclear safety the overriding priority.*
>
> The following principles are described in the document:
>
> 1. Everyone is personally responsible for nuclear safety.
> 2. Leaders demonstrate commitment to safety.
> 3. Trust permeates the organization.
> 4. Decision-making reflects safety first.
> 5. Nuclear technology is recognized as special and unique.
> 6. A questioning attitude is cultivated.
> 7. Organizational learning is embraced.
> 8. Nuclear safety undergoes constant examination.

The INPO principles capture the behaviors and values that the SLT needs to demonstrate and reinforce across the organization, mainly through manager / staff interactions.

My Definitions of Safety Culture (from the definitions section of my industry presentation)

> Safety Culture, Business Ethics
> A type of ethical business or organization culture that proactively manages activities such that people are protected from physical harm.
>
> Safety Culture, Human Performance
> A human performance safety system that requires regular surveillance, maintenance and quality assurance equal to that provided for an electro-mechanical safety system.
>
> Safety Culture, Quality Control
> Controlling the SOE risk introduced by human performance. A quality safety culture maintains the human performance element of SOE risk ALARA: *As Low As Reasonably Achievable*.
>
> Safety Culture, High Hazard Venture Organization (Nuclear Power Operation etc.)
> The ethical attitude within a high hazard venture organization, instilled and maintained by the managing leadership, which ensures a hazardous activity first does no harm to people or the environment.

Summary and conclusions

These are the summary concepts:

1. The problem with assessment approaches used in the past is that the metrics chosen to

indicate safety culture health are also influenced by many other factors.

2. .NRC, IAEA and INSAG often treat them as interchangeable, but safety culture is only one component of human performance. Human performance focuses on both *reducing errors* and *managing defenses* to create immunity to significant events. Safety culture falls under the *managing defenses* part of the formula in the *cultural/leadership* area. When you perceive safety culture as all safety related human performance activities on a site, you lose the ability to reliably assess safety culture because:
    a. The quality of the human performance activities will be influenced by many factors other than safety culture
    b. The task is so large as to be unmanageable
    c. Think of it in terms of managing the human body. There are thousands (millions) of processes inside the workings of the body that are outside of your control. However, you do control some fundamental factors that have a fundamental affect on all the other processes: how you sleep, how you eat, and how you exercise. How you do these things depends on your personal *culture*.
3. The key to assessing culture is not to look at <u>what safety culture acts upon</u> (as anything here would be influenced by other factors) but to look at <u>what acts upon safety culture</u>. Industry guidance tells us that more than any other factor what determines the quality of the safety culture are the actions of the SLT – the Site Leadership Team.

**Again, INPO's latest definition for safety culture:**

> *Safety culture: An organization's values and behaviors—modeled by its leaders and internalized by its members—that serve to make nuclear safety the overriding priority.*

I was very glad to see this new definition. I have been petitioning the industry for an improved definition for years. I am a believer in the management formula *define – measure – manage*. To <u>manage</u> anything effectively you first need to be able to <u>measure</u> it reliably, to <u>measure</u> anything reliably you first need to be able to <u>define</u> it clearly.

This simple change from the old "ambiguous" INSAG definition to a clearer, more accurate definition I believe is eventually going to help the industry do a better job of understanding and managing safety culture. ORSIM should draw guidance from the INPO definition and seek to model:

1. How effectively leaders are modeling values and behaviors
2. How effectively the members have internalized values and behaviors.

There are standard culture data acquisition methods rooted in the works of culture experts such as Drs. Schein, Reason, and Carroll that are proven and effective. They observe culture "artifacts" through field observations, surveys, focus groups and interviews. I have personally worked with these approaches at Millstone, successfully evolving and refined (optimizing) them and they are ready for general application in nuclear power plants and HROs.

I look forward to discussing these SC assessment concepts with you, perhaps largely "new" to the industry, but vetted and derived from the work of culture experts, metrics and methods that have been proven effective for culture assessment and remediation at Millstone and elsewhere.