**Organizational Health – New Methodology for Measuring**

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**Executive Summary**

Much has been written about the importance of a company’s ‘safety culture’ in terms of strong personnel & process safety performance. This study builds on that and examines ‘organizational health’, what it consists of, how it is measured and keys to improvement. Although easily confused with safety culture, organizational health focuses on a combination of both the culture and capability of an organization. A company must possess the correct tool set of both data and knowledge to improve their organization’s capabilities, safety culture, and, ultimately, organizational health. The precise utilization and sustainability of this tool set promotes a malleable safety culture that can be evaluated with steps for improvement. The use of this tool set allows any company to identify and then fill in the undeveloped gaps in their organizational health. The American Chemistry Council discusses this advanced approach to understanding safety culture, “Arriving at a point where safety culture was potentially part of our organizational dialogue represented a significant shift in the way many levels of the organization defined and understood risk, safety, failure, error, accident causality, and accountability” (1).

Building on ideas presented by McKinsey Quarterly (2), as well as executing rigorous research, this work has constructed a model to define the key parameters contributing to good organizational health within a business. In addition, numerous suggestions along with specific behavioral and operating elements are provided to assist companies in improving their organizational health based on which aspects are lacking from the models provided. At the highest level, organizational health is composed of organizational culture and organizational aptitude. While these are two separate aspects of organizational health, in order to maintain and design a healthy company, both branches must cohesively work together.

Additionally, recommendations and action items are provided to companies in order to design, improve, and support their organizational health through the use of an organizational health metric support table (*Table 1-3*). This table provides a thorough list of ‘must haves’ and ‘must wins’ to aid in success for each element of organizational health presented. Finally, example cases of incidents in industry and their root causes are evaluated to show how shortcomings in organizational health can lead to disaster.

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# Introduction

Organizational health is an important component of a company’s sustainability. McKinsey & Company define organizational health by stating, “We think of organizational health as more than just culture or employee engagement. It’s the organization’s ability to align around a common vision, execute against that vision effectively, and renew itself through innovation and creative thinking. Put another way, health is how the ship is run, no matter who is at the helm and what waves rock the vessel.” (2). Most companies will not stay ‘excellent’ over a long period of time and many do not succeed at promoting organizational-change programs. Companies which overcome these odds will surely thrive and create meaningful and rewarding careers for all employees. Businesses must fully adopt each element of organizational health to boost performance and develop an ability for continuous improvement. Leadership must be open to discuss which components of their organizational health need improvement, how they want to fix those aspects, and if they are truly ready to make changes. Providing your organization with the capacity to learn and the motivation to make continuous change will preserve high performance and successful organizational health.

There is currently a void in the area of organizational health as no specific metric exists for a company to baseline or measure their current health and be provided resources to improve and grow. The lack of organizational health metrics is challenging for industry as high performance is difficult to achieve without the proper resources. This research provides an organizational health metric fishbone model to assess the current health of a business, in addition to an organizational health metric support table which provides a list of safety standards, methods, and programs to improve any health element. These resources will provide opportunities for many companies to establish a sustainable and innovative way to measure their organizational health, make the necessary changes to achieve a high performance, and gain a competitive advantage.

# Analysis

Key references used to build the fishbone model include presentations, analyses, and articles submitted by industry leading safety organizations and experts. Marsh & McLennan - a leading professional services firm in the areas of risk, strategy, and people - provided detailed presentations on process safety, developing safety culture, and incident learnings (3). The American Chemistry Council - representing a diverse set of chemical companies - offered resources to provide insight in the fields of occupational health and safety culture. Behavioral Science Technology, Inc. (BST) introduced the concept of organizational aptitude and organizational culture in addition to providing many key elements to the fishbone (4). The Center for Chemical Process Safety (CCPS) contributed analyses about all process safety aspects including leading and lagging indicators (5). Many additional resources, including interviews with safety executives, were utilized to complete the organizational health fishbone and research. *Appendix A2* also provides a multitude of incident investigations which highlight key factors of the fishbone model that were lacking or missing at the time of the incident. These investigations tie the incident root causes to specific organizational health elements to highlight the potential for incident mitigation or decreased severity through application of the organizational health fishbone model.

## **Fishbone Model**

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#### Figure 1: Organizational Health Fishbone

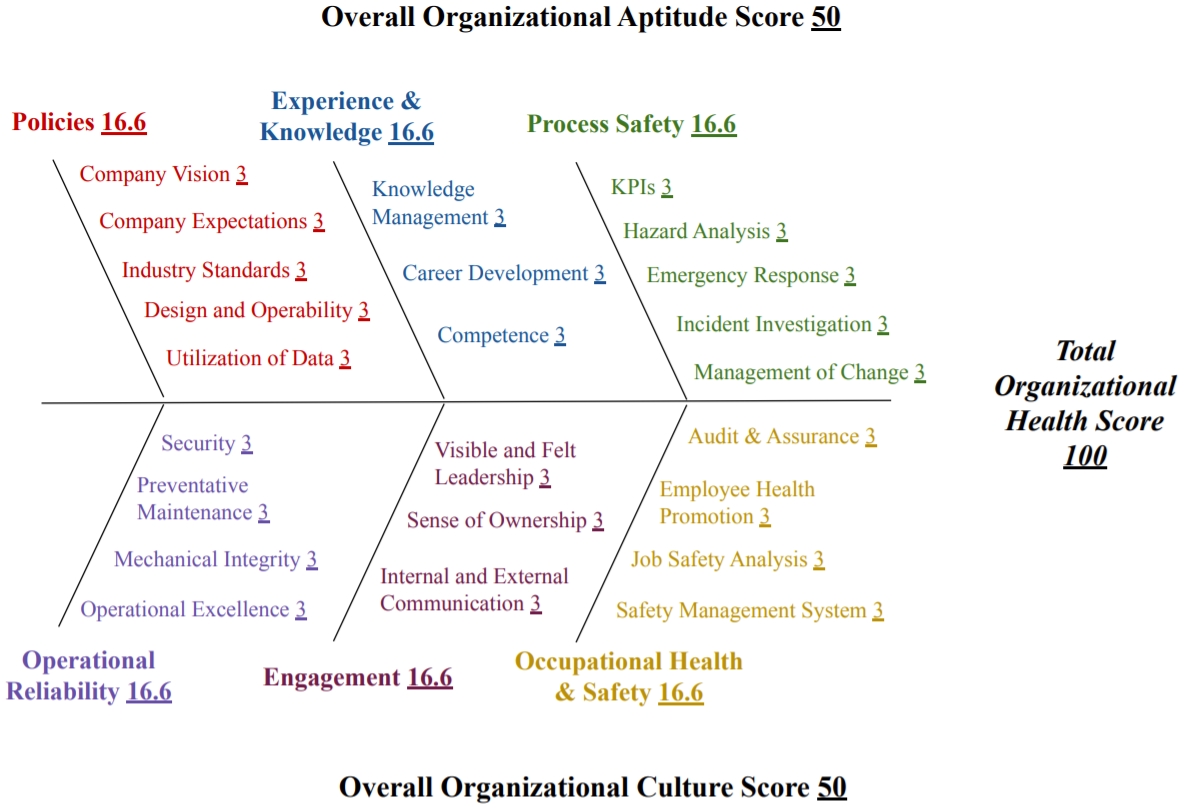
#### Fishbone lists six key elements of organizational health at the end of each branch. Components making up these key elements are seen along the corresponding branch.

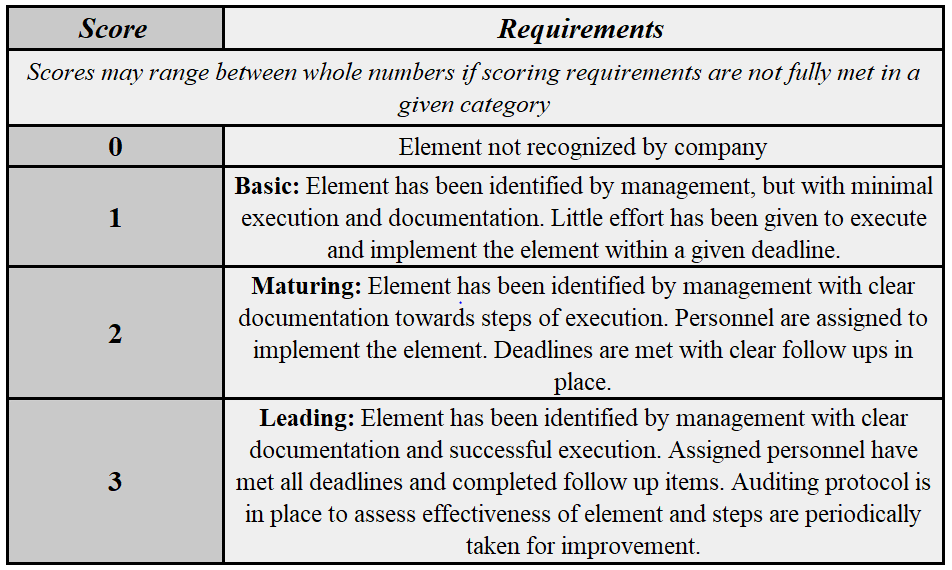
A fishbone model was created to visually represent the key factors of organizational health, as shown in *Figure 1*. This model is composed of organizational aptitude - as seen on the top half of the fishbone - and organizational culture - as seen on the bottom portion of the fishbone.

Organizational aptitude is defined as a company’s ability to utilize its specific tool set of knowledge, experience, data, and analytic tools to build a strong backbone and support process safety throughout the organization. Organizational aptitude is the utilization of experience and knowledge, based on a company’s core vision and expectations, to support process safety. Regardless of policies set forth by a company, without proper application of experience and knowledge, one cannot expect to fulfill the needs required to maintain and support process safety, an essential component of organizational health. A strong organizational aptitude requires people with the right knowledge and experience to be placed in the right roles which are supported by sufficient data and policies. By drawing upon this pool of knowledge and data, process safety - a key component of organizational health - can be sufficiently supported. Each bone under organizational aptitude consists of policies, experience and knowledge, and process safety as the leading parameters. The main bones of organizational aptitude are then allotted into further subsections. In the policies section, the subsections include company vision, company expectations, industry standards, design and operability, and utilization of data. Experience and Knowledge consists of knowledge management, career development, and competence. Process safety is composed of key performance indicators (KPIs), hazard analysis, emergency response, incident investigation, and management of change. The asterisk (\*) seen adjacent to KPIs and incident investigations indicates these elements are also included under the occupational health and safety bone on the organizational culture side of the model.

Organizational culture is defined as the extent in which a company supports their safety culture through reliable operations, internal and external engagement by all levels of the business, and the ongoing support of each employee’s safety. Organizational culture directly relates to a company’s safety culture and the extent to which it is designed and supported. As defined by BST, organizational culture is “The underlying, unstated, shared beliefs and values that exist within an organization. Behavioral norms, such as how closely procedures are followed to where people sit in meetings.” (4). For the organizational health fishbone model (*Figure 1*), organizational culture contains the main bones of operational reliability, engagement, and occupational health and safety. A strong organizational culture includes creating an environment where senior executives, mid-level managers, and front-line workers all demonstrate a sense of ownership and hold accountability of safety supporting actions. Organizational culture has main bones consisting of operational reliability, engagement, and occupational health and safety. These bones are then apportioned to additional subsections. Operational reliability includes security, preventative maintenance, mechanical integrity, and operational excellence. Engagement consists of visible and felt leadership, sense of ownership, and internal and external communication. Occupational health and safety contains audit and assurance, employee health promotion, job safety analysis, and safety management systems. The asterisk (\*) seen adjacent to safety management system indicates this element is also included under the process safety bone on the organizational aptitude side of the model. *Appendix A1* provides a detailed analysis and explanation of each main bone and sub-element in the fishbone to aid in understanding and associated scoring of the model.

The fishbone scorecard shown as Figure 2 serves as a way for companies to strategically assess their organizational health. The scoring guide is based on a maturity model to evaluate the current effectiveness of each bone and subsection as “basic”, “maturing”, or “leading”, as defined in Table 1. Each subsection is scored from 0 to 3 with the main bones adding to a maximum score of 16.6. This total is weighted for each bone as the number of subsections are not equivalent (3-5 for the various areas). The top and bottom sections for organizational aptitude and organizational culture total to maximum of 50 with a maximum organizational health score of 100. This tool can pinpoint areas of excellence and areas with opportunity for improvement throughout the fishbone model. The feedback gathered from evaluation of the fishbone scorecard directly translates to the metric support tables defined below.

*Figure 2: Organizational Health Fishbone Scorecard*



*Table 1: Scoring Guide for Organizational Health Fishbone Scorecard*

# Organizational Health Metric Support

The organizational health metric support tables (*Tables 2-4*) are intended to act as supplemental resources for the fishbone model. These tables provide a baseline list of safety standards, methods, information, and programs to improve upon or properly maintain each organizational health element. Each main bone and subsection are assigned a table of factors shown in either a blue or amber color. The blue color indicates elements which are essentials or “must haves” in the given section of the fishbone model to showcase sufficient understanding and operability of organizational health. The amber color illustrates excellence or “must wins” in the given section of the fishbone model. Incorporation of the amber elements means a company is exhibiting behaviors and practices which reflect high performing organizational health. The metric support tables also contain a scoring column and use the same scoring mechanism as shown in *Table 1*. Each element on the table can be scored as 0-3 and is totaled at the bottom of each column / main bone. The essential elements (blue color) are weighted by 1.0 and the elements of excellence (amber color) are weighted by 1.5, arbitrarily weighting the amber elements of excellence 50% more than the others.

The metrics for Policies surround the implementation, utilization, and auditing of regulations and standards in the workplace and ensuring operating conditions are properly assessed by thorough data analysis. Additional metrics ensure the proper systems and accountabilities are in place to sustain a well-understood company vision and assist employees in following the associated expectations. The metrics for Experience & Knowledge pertain to a multitude of topics surrounding the development of employees from the onboarding process, career advancement, and assessment of competency. Third party involvement in safety protocol / training is also included in these metrics along with development of leadership qualities. Process Safety metrics include various programs to steward safe operation of the facilities and equipment including hazard recognition, alarm management, management of change, et al. Utilization of process safety data by management to establish proactive recognition of process safety hazards is also included in these metrics.

The metrics for Operational Reliability relate to the proper inspection and maintenance procedures for both basic and safety critical equipment. Security associated with the physical plant and cyber operations are also metrics in this section. The Engagement table contains metrics relating to the appropriate management and communication of safety incidents throughout the company and community. These metrics also reference the identification and engagement of safety personnel in company and community affairs. The final element of Occupational Health & Safety has metrics surrounding the stewardship of employee heath through multiple programs and safety protocols. Management and supervisor involvement in safety management systems is also included in these metrics. If clarification is needed for terminology in the metric support tables or fishbone model, *Appendix A3* is available as a resource. The terms defined here directly relate to their application in this paper.

#### Table 2: Organizational Health Metric Support Table

#### (Policies / Experience & Knowledge)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | ***Policies*** | ***Score*** | ***Experience & Knowledge*** | ***Score*** |
| ***Company Vision, Company Expectations, Industry Standards, Design & Operability, Utilization of Data*** | ***0-3*** | ***Knowledge Management, Career Development, Competence*** | ***0-3*** |
| **Essentials x 1** | Compliance with applicable laws & regulations, licenses, permits, codes, etc. (Documented and accessible) |  | Learning Management System: Knowledge assessment, refresher training, etc. with clear documentation and assessment of effectiveness |  |
|  |
|  |
|  |
| Drawings, records, & documentation for design, operation, inspection & maintenance readily accessible |  | Onboarding programs for new hires, including mentorship |  |  |
| Ensure compliance and understanding of company expectations- safety management system in place with clear accountability |  | Contractor Management Program in place: Ensure contractors are aware of hazards, risks, and mitigations at operating sites |  |  |
| Assessment of operating conditions to confirm if within safe operating range through use of models, data analysis, etc. |  | Make process safety performance and leadership significant considerations in career development |  |  |
| Develop and provide training on internal standards to share engineering design and operating knowledge |  | Career development plan and ongoing screening for all employees enabling them to reach their potential with well thought out assignments |  |  |
| Operations safety audits addressing maintenance, inspections, operating procedures, recent incidents, etc. |  | Personnel management of change criteria in place to ensure adherence to operating standards |  |  |
| Utilize OSHA PSM standards to establish specific performance objectives, regardless as to whether required by regulations |  |  |  |  |
| **Excellence x 1.5** | Periodic survey of existing safety culture/attitude |  | "Storytelling" Safety Training |  |  |
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|  |
| Assess applicability of guidelines for process safety issued by the Center for Chemical Process Safety, et al |  | Implement personal-leadership workshops to develop employees’ ability to improve continuously |  |  |
| Work with regulators to make standards effective and efficient |  | Promote external / 3rd party education & training to ensure competence with respect to company standards |  |  |
|  |  | Encourage contractors to participate in development and implementation of safety systems |  |  |
|  | **Total Score** |  | **Total Score** |  |  |

#### Table 3: Organizational Health Metric Support Table

#### (Process Safety / Operational Reliability)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | ***Process Safety*** | ***Score*** | ***Operational Reliability*** | ***Score*** |
| ***KPI's, Hazard Analysis, Emergency Response, Incident Investigation, Management of Change*** | ***0-3*** | ***Operational Excellence, Mechanical Integrity, Preventative Maintenance, Security*** | ***0-3*** |
| **Essentials x 1** | Tier 1 & 2 Process safety metrics part of KPIs and stewarded by senior management |  | Mechanical Integrity Program (testing, inspection, & maintenance) |  |
|  |
|  |
|  |
| Alarm Management (prioritization of alarms, action plan for each alarm, etc.) |  | Safety Critical equipment identified & included in PM with designated roles and responsibilities |  |  |
| Process hazard analysis completed every 3-5 years and actions taken to complete recommendations |  | PM Completed (% On Time) with goals and follow up, as appropriate |  |  |
| Internal inspection and audits completed on process safety hazards |  | Business continuity & crisis management plans, including periodic drills |  |  |
| Active hazard recognition program |  | Monitoring of physical & cyber security breaches |  |  |
| Safe work permits properly completed (Lockout – Tagout, Hot Work, etc.) |  | Turnaround planning (scope, schedule, etc.) |  |  |
| Companywide Life Saving Rules developed and practiced |  | Safety Control System information collected & processed for improvement (nuisance alarms, facility downtime, etc.) |  |  |
| Management of Change processes uniformly applied |  |  |  |  |
| % Root Cause Analysis completed following incidents & shared internally |  |  |  |  |
| **Excellence x 1.5** | Tier 3 & 4 Process safety metrics & appropriate leading indicators developed & implemented |  | Safety culture initiative scores (Safety programs differ per company) |  |  |
|  |
|  |
|  |
|  |
| Clarify understanding of acceptable/unacceptable risk tolerance |  |  |  |  |
| GEMBA: Safety walk & discussions with operators |  | Vibration Monitoring Program (Rotating Equipment) |  |  |
| Risk matrix applied with risk register to document significant risks |  |  |  |  |
|  | **Total Score** |  | **Total Score** |  |  |

#### Table 4: Organizational Health Metric Support Table

#### (Engagement / Occupational Health & Safety)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | ***Engagement*** | ***Score*** | ***Occupational Health & Safety*** | ***Score*** |
| ***Internal and External Communication, Sense of Ownership, Visible and Felt Leadership*** | ***0-3*** | ***Safety Management System, Job Safety Analysis, Employee Health Promotion, Audit & Assurance*** | ***0-3*** |
| **Essentials x 1** | Process & personnel safety incidents communicated internally & externally |  | Safety Management Systems core elements are in place with roles, responsibilities, authorities, & accountabilities known |  |
|  |
|  |
|  |
| Training completed for all EHS roles |  | Steward OSHA recordable injury illness rates with annual goals |  |  |
| Legislative monitoring for environmental and community affairs |  | Managers & supervisors credibly demonstrate commitment to safety culture |  |  |
| Emergency planning meetings with community and LEPC |  | Ergonomics program in place– policy, program scope, and KPIs |  |  |
| Engagement/Participation with external Safety Organizations (OSHA, EPA, CCPS, etc...) |  | PPE identified & available for appropriate situations |  |  |
| Role of operations versus EHS staff on safety processes clearly identified |  | Employee HR assistance available for health care and wellness related needs |  |  |
|  |  | Job Safety Analyses (JSA’s) completed with goals and follow up |  |  |
|  |  | Fitness for duty (% Completed) |  |  |
|  |
| **Excellence x 1.5** | Presence of community affairs for engagement with facility neighbors |  | Sponsored health screenings and wellness promotions |  |  |
|  |
|  |
|  |
|  |
| Sustainability Stewardship (Water utilization, renewable energy, recycling, etc.) |  | Employee assistance programs offered – gym discounts, activity promotions, etc. |  |  |
| Proactive communication of upcoming process safety events with community (eg. Flaring with unit startup) |  | Fatigue Management Program for shift / work scheduling |  |  |
| EHS professional certifications earned (eg. CSP) |  | Support work-life balance programs |  |  |
|  | **Total Score** |  | **Total Score** |  |  |

**Industry Experience with Methodology**

The fishbone model survey and metric support tables were quality tested by multiple industry partners. Company A, B, and C were asked to complete both the fishbone survey and metric support tables and provide thorough feedback on ease of use, opportunities for improvement on the quality of each element / metric, and suggestions for any missing or lacking elements / metrics. The feedback received from these completed “road-tests” was immediately applied to the existing models. The interaction between the research team and Company A, B, and C allowed for the quality and applicability of the organizational health models and scoring metrics to significantly improve while providing the industry partners with a new opportunity to improve upon and bring awareness to the organizational aptitude and culture of their company.

Company A was also able to participate in an analysis meeting of their results for the organizational health metrics completed. This analysis meeting included graphical analysis of the support metric table scores, indication of the highest scoring fishbone elements, and indication of the lowest scoring fishbone elements. After presenting these results to Company A, the company’s team members were able to communicate and determine focus areas for improvement.

**Conclusions**

The development of an organizational health model and support table provides companies an opportunity to establish a baseline measurement of their organizational health and develop a course of action for improvement opportunities. If a business fully adopts the practices aforementioned in this research paper, there is great opportunity to increase performance and continuously improve each metric of organizational health and the overall safety culture of a company. The use of the fishbone model helps to determine the two key components that make up organizational health: organizational aptitude and organization culture. These consist of the main health metrics including policies, experience & knowledge, process safety, operational reliability, engagement, and occupational health & safety. If these elements are properly reviewed, enforced, and audited then a safer and healthier work environment will be created.

**Recommendations**

Future work of this research team includes finding industry partners to pilot or implement this organizational health metric tool with their daily practices and await feedback on the effectiveness of the model. The impact of this work intends to change the way businesses look at both their safety culture and organization’s health. The metrics created will assist in creating a better and safer performing workplace.

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# Appendix

## A1. Fishbone Element Analysis

Each key factor and subsection of the fishbone are thoroughly described and defined below to help companies and professionals assess each of these components of organizational health.

# Organizational Aptitude

## Policies

The first key parameter of organizational aptitude in the Fishbone model is “policies”. Strong organizational health relies on a company’s ability to align around a common vision and execute that vision effectively based on a company’s expectations. Having clear policies and adherence to industry standards (ARI RP, CCPS, etc.) in process design and operability allow a company’s behaviors and availability of data and information to become sustainable over time. If a company fails to comply with and advocate for use of all standards surrounding operation of the business, there is a limiting foundation for that company to grow and advance their safe operations. Policies, and a company’s ability to effectively apply these policies, create a strong backbone for process safety culture and greatly improves the organizational aptitude of the business.

Continuous and consistent policy and procedure reviews and verifications - along with proper application - are key steps to ensuring the strength of this company backbone. Without policies in the workplace, there would be limited direction for safe and proper growth and direction within an organization.

### Company Vision

The “policies” branch of the Fishbone is first broken down to “company vision”. This element promotes the importance of a shared company vision which should be clearly understood by each employee and contractor on site. Many businesses can be seen with an eye-catching poster of their company vision hanging in the halls of the office as a daily reminder of their goals and motivational force. Other businesses may use their company vision as a source of focus to kick off a manager’s meeting or begin the onboarding process to inspire new employees. An article from the McKinsey Quarterly describes the importance of a company vision, “We think of organizational health as more than just culture or employee engagement. It’s the organization’s ability to align around a common vision, execute against that vision effectively, and renew itself through innovation and creative thinking... It’s about sharing a company’s vision and mission in a way that inspires employees to act in its best interests” (6). As a facility develops its company vision, it must first show clear direction and innovation to not only unite all of the employees, but also excite and motivate them to commit to and exercise it. True success of a company vision can be seen through the execution and application of each component - each employee should use the vision as a guide with everyday decision making.

### Company Expectations

The next element under policies is company expectations which utilize the company vision to establish a well-known set of standards for each employee to adopt in their daily work. Although each staff member may have a different job title and roles, it is the responsibility of the business to ensure each of their employees follow the integrated company expectations along with job specific expectations. This element is important to align on proper behaviors, motivations, and culture throughout the entire workplace. Laurence Pearlman, a Sr. Vice President from Marsh Risk Consulting, elaborates on how company expectations add to a suitable safety culture, “There must be a foundation of clear expectations that are known, followed and reviewed in order to achieve behavioral change” (3). To effectively enforce company expectations, leaders must demonstrate care for their employees by sharing safety stories, observing work and actions at the facility, and having conversations to - most importantly - praise safe work or improve upon unsafe actions. This engagement between management and other employees will remove the perspective of company expectations being a simple “list” and create a culture where expectations are in place to link all layers of the business and enforce behaviors to unite the workplace.

### Industry Standards

Following company expectations under the policies bone is industry standards. Industry standards, national and international codes, local and federal regulations, and laws are a cornerstone of organizational aptitude excellence. Keeping track of and adhering to evolving industry standards (API RP, CCPS, etc.) can be a tall task so it is imperative that systems are in place to identify, assess, and maintain a clear record of all standards relating to the business and operations. As standards are constantly being added, changed, or developed, it is also critical that systems are in place to monitor these changes. The key standards should also be made easily accessible for all users including both contractors and employees. Industry standards are in place to ensure businesses operate in the safest manner and for example, address on-site hazardous materials and processes.

### Design and Operability

The next element under policies is design and operability. This element refers to having a clear and available record of all onsite equipment details, process design information, and operational procedures for a myriad of operating conditions. This subsection can include an overwhelming amount of documentation and data storage; however, it is one of the most important elements to ensure safe operation of a facility. Equipment details include understanding and keeping records of all drawings, PFDs, P&IDs, manufacturer documents, operational details, and safety features of all equipment on site. These details should be mastered and easily accessible by any operators working directly on or with the equipment. Process design information is imperative to understanding all potential hazards associated with the process at hand. Clear documentation of the process is the first stage in properly identifying safe operating procedures and all hazardous process conditions. All personnel must understand the operational procedures on the unit they are working on to ensure safe operation. The standard operating procedures should include normal, transient, start-up, shut-down, et al operations as each situation yields different steps and hazards, as required by OSHA process safety management. Operators should master all standard operating procedures as a job requirement.

### Utilization of Data

The final element under policies is utilization of data which refers to the base information required to manage process safety. Scott Stricoff from Behavioral Science Technology, Inc. (BST) describes the importance of utilization of data, “Information on the flammable properties, toxicity, and reactivity of chemical substances, and on the compatibility of chemicals with each other and with the equipment is critical to our understanding of risk and determination of adequate risk control. Information is derived from data, and data must be validly obtained and appropriate to the situation” (4). Data and information can be used to predict consequences of incidents in addition to drawing conclusions about complex chemical and process relationships. Organizational aptitude relies on proper sources of data, information, and the conclusions drawn from them. If the right data is used by people with the proper skills, knowledge, and experience, then exceedingly strong process safety can be achieved.

## Experience and Knowledge

The next bone in the organizational aptitude portion of the fishbone model is experience and knowledge. Adequate depth of knowledge is vital to producing thorough, meaningful work and detailed data analysis in the workplace. Capturing and sharing knowledge and experience is also vital, as it contributes to competence of employees and overall company success. Employees must be able to not only know the steps of each job requirement and safety protocol but also be able to understand the reasoning behind the techniques and fundamental objectives of the task. Employees must also portray practical knowledge in addition to book knowledge. Practical knowledge is developed through one’s career path and experience in addition to strong mentorship and guidance. As all aspects of experience and knowledge are applied and institutional knowledge is properly drawn upon, organizational aptitude is significantly improved.

### Knowledge Management

The first subsection under experience and knowledge is the concept of knowledge management. Knowledge management means ensuring proper transfer of information from older to younger generations, incorporating “storytelling” into safety training to allow true experience to teach valuable safety lessons, and using documentation of adverse events as learning lessons. Dale Rosene, an Environment, Health, and Safety Director from GlaxoSmithKline, speaks on the importance of knowledge management throughout his company, “Experience really does make a difference. The old information and thought processes are still very helpful but need to be applied in new and efficient ways. You need to blend these elements together in order to make your safety culture work and the world safer” (7). To share this knowledge and experience between experienced employees and new hires, some companies may utilize various mentorship programs or provide job specific training for the transition of roles from more experienced to less experienced employees. Companies need to hold the older generation of employees accountable for this transfer of knowledge and also need to provide avenues to make this possible. Additionally, the benefit of storytelling during safety training allows for new employees to hear a first-person perspective from a safety incident. This provides the insights and knowledge needed to ensure the incident does not happen again. Lastly, incorporating findings from past safety incidents into new employee safety training will allow new employees to be aware of hazards present and the mitigative steps taken to eliminate these hazards.

### Career Development

The following element under the experience and knowledge bone is career development. This subsection prioritizes that people and systems are in place to ensure employees with the right knowledge and experience are in the right roles and on a path to achieve their career goals. Sound conversations between leadership and employees are imperative to establishing a clear career development path which accounts for both the employees’ practical skill sets and also their career aspirations. Advancement in one’s career development pathway should include, but is not limited to, current job role execution, process safety experience and milestones, desire for increased responsibility, experience and knowledge surpassing the current role, and employee actions aligning with company vision and expectations. Leadership personnel or supervisors should be made available to each employee as a career development mentor to have transparent conversations. Transparency between leadership and an employee’s career path allows for increased motivation and improved organizational aptitude.

### Competence

The final element under the knowledge and experience bone is competence which is best described by Steve Arendt - a Director and Vice President for Operational Performance Assurance from ABS Consulting - in *World Energy Magazine*, “The process safety competence element includes three interrelated objectives. The first is to learn new things continuously. The second is to make sure that appropriate information is available to operators and other front-line personnel in a manner that helps them make sound decisions. The third is to try not to forget what has already been learned. The learning aspect includes efforts to develop, discover or otherwise enhance process safety knowledge” (8). To “learn things continuously” may seem like a natural part of any job role; however, this can be promoted through many different programs used by management. These programs can include knowledge screenings and assessments of personnel’s competency throughout different time periods in their job role, cross training with unfamiliar roles, or participation in transient operations of the facility. In order to learn things continuously, the proper information and training tools must be made available to all employees on their specific units. Standard operating procedures, records of historic maintenance needs and operational obstacles, and clear process diagrams where all materials must be made easily accessible to all personnel involved. Additionally, retention of this wealth of knowledge greatly contributes to an employee’s competency. Ensuring all knowledge learned is clearly retained can be accomplished through different assessment methods that differ from company to company.

## Process Safety

Process safety is the final bone under the organizational aptitude portion of the fishbone model. Although process safety contains many moving parts and pieces, one clear definition is given by the International Association of Oil & Gas Producers, “Process safety is a disciplined framework for managing the integrity of operating systems and processes that handle hazardous substances. It relies on good design principles, engineering and operating and maintenance practices. It deals with the prevention and control of events that have the potential to release hazardous materials and energy.” (9) There are many elements which are necessary to support every aspect of process safety; and these elements must be properly executed to assure the workplace avoids release of hazardous materials and energy, reduces major disaster risk, and improves industry performance. Process safety is intended to protect both people and the environment through the use of the subsections found below in combination with other process safety management factors. The latter include for example other elements of OSHA Process safety management, such as training, contactors, several of which are addressed under other bones of Organizational Health.

### KPI

The first element under the process safety bone is KPI, or key performance indicators, which include leading and lagging safety indicators, goals, minimum requirements, and continuous improvement. These quantitative values showcase the effectiveness in which a business is achieving their key objectives. Simply put, one must define measures applicable to desired areas of improvement. KPIs are a tangible component of organizational aptitude which must include robust and sufficiently governed data and systems required for effective process safety management. Tools must also exist and be used appropriately to support management’s ability to acquire ample reporting to fully understand root cause and trend analysis. Additionally, any metrics in place must focus on both lagging and leading indicators (hazard reporting, risk matrices, etc.) which fit each company’s approach to process safety. KPIs should be tailored to monitor and best develop an effective safety management system and be properly utilized to fit the company’s safety objectives (3).

### Hazard Analysis

The following element under KPI is hazard analysis which is a leading indicator associated with process safety. Proper hazard analysis, identification, and management must be instituted in addition to proper risk ownership with clear deadlines. Authors of the Chemical Process Safety textbook, Daniel Crowl and Joseph Louvar, describe requirements surrounding a proper hazard analysis, “Process hazard analysis (PHA) must be performed by a team of experts, including engineers, chemists, operators, industrial hygienists, and other appropriate and experienced specialists. The PHA needs to include a method that fits the complexity of the process, a hazards and operability (HAZOP) study for a complex process, and for less complex processes a less rigorous process, such as what-if scenarios, checklists, failure mode and effects analysis, or fault trees. Employers must ensure that the recommendations from the PHA are acted on in a timely manner. Every PSM process needs an updated PHA at least every five years after the initial analysis is completed.” (10) The purpose of a hazard analysis is to proactively identify hazards before an incident occurs. Once these hazards are determined, expeditious actions can be taken to reduce all risks associated with the process. Hazard analyses can fall short if clear risk ownership is not identified with a clear deadline for completion. Management systems must be in place to ensure these hazards are removed or mitigated in a timely and effective manner.

### Emergency Response

The next element under the process safety bone in the model is emergency response. Steve Arendt once again relays the key elements of emergency response in *World Energy* Magazine, “Emergency management includes 1) planning for possible emergencies, 2) providing resources to execute the plan, 3) practicing and continuously improving the plan, 4) training or informing employees, contractors, neighbors and local authorities on what to do, how they will be notified and how to report an emergency, and 5) effectively communicating with stakeholders in the event an incident does occur” (8). All of these five elements must be included to yield a successful emergency response plan for a company. Determining the appropriate emergency response should also address several categories including, but not limited, to security threats associated with the emergency, safety and human health factors, fire and explosion possibilities, any potential chemical toxicity impacts, and the impact on the community and environment. Emergency response plans should be well communicated with all employees and contractors on site and practiced with high frequency, so all know their roles and expectations. The Center for Chemical Process Safety provides additional requirements for emergency responses, “...the administrative controls include emergency response plans with trained internal and/or emergency responders. There are two aspects to emergency response which are considered: 1) Internal – facility resources only; and 2) External – with both internal and external, community resources” (5).

### Incident Investigation

Incident investigations are another key element under process safety. All aspects of the incident are covered including “how and what we communicate”, “what failed and how do we message it”, “learning”, and “taking action”. Communication of the incident needs to be both concise, simple, and include only relevant information. Overcomplication of the message can lead to unclear understanding of the root causes and sequence of events associated with the incident. In order to decide what failed leading to the incident, it is important to analyze if the proper rules and standard operating procedures were in place and whether or not they were chosen to be followed. Investigation of an engineering or design failure in addition to the system and safety culture failures must also be analyzed. To properly learn from an incident, all layers of the business must be engaged to properly discuss incident findings and ask the question “how”. The incident learnings should also be translated into a storytelling message in order to increase the impactful nature. Once the root causes of the incident have been determined, more action must be taken to ensure procedures are updated, proper Management of Changes have been performed, changes have been communicated to all employees, and documentation from the incident has been made easily available for all. (11)

### Management of Change

The final subsection under the process safety bone of the model is management of change. Steve Arendt in *World Energy* Magazine again explains the importance of management of change, “Change management is a process for reviewing, evaluating and authorizing proposed adjustments to facility design, operations, organization or activities – prior to implementation – to make certain that no unacceptable hazards are introduced and that the risk of existing hazards to employees, the public or the environment is not increased above a tolerable level” (8). Management of change is an important element to ensure any risks associated with change in the process are properly identified and mitigated. ExxonMobil further describes a detailed process for management of change through their Operations Integrity Management Systems - Element 7 - including authority for approval changes, compliance with regulations and approved standards, acquisition of needed permits, reason for change, communication of risks associated with the change and required mitigation measures, time limitations, and training. (12) Note that this definition also addresses personnel changes, training, and competence.

# Organizational Culture

## Operational Reliability

The first bone under organizational culture is operational reliability. Operational Reliability is the ability of an organization to maintain safe operations, regardless of external events that may increase the possibility of incidents from occurring. Reliable operations cannot be maintained without support of employees and their mindset regarding incident prevention and mitigation. BST describes reliability as, “Doing the right things, in the right way, at the right time, every time. This means that the “unwritten rules'' in the organization must be consistent with the objectives of process safety.” (4).

### Operational Excellence

The first subsection under the operational reliability bone is operational excellence, a broad and important feature. It has been defined as, “The workplace philosophy where the combination of problem-solving, teamwork, and leadership results in ongoing improvement in an operation.” (13). Worker behavior is a common root cause of incidents which can be reduced by providing training to identify and control hazards, communicating safety concerns, prioritizing safety over production, communicating expectations, and holding everyone accountable. This statement is supported by a statement from BP in regard to operational excellence, “By providing frontline supervisors and leaders with skills to promote healthy communication and a feedback loop that encourages honest, accurate information, companies will see more than just positive safety results. They will realize sustainable operational excellence.” (14)

### Mechanical Integrity

The next subsection under operational reliability is mechanical integrity. Mechanical integrity is one of the fourteen elements in OSHA’s process safety management (PSM) standard. When describing mechanical integrity, the American Petroleum Institute states, “Mechanical integrity includes equipment/assets such as pressure vessels, storage tanks, piping systems, and associated hardware (valves, fittings, etc.), relief devices, and emergency shutdown/control systems. It encompasses the activities necessary to ensure that equipment/assets are designed, fabricated, installed, operated and maintained in a way that provides the desired performance in a safe, environmentally protected, and reliable fashion.” (15). An effective mechanical integrity program should identify critical equipment, that requires preventive or predictive maintenance, as well as that requiring little or no maintenance – recognizing that all equipment has unique requirements. The actions taken by the employees, in supporting mechanical integrity, ultimately determines the effectiveness of ensuring safe operations. There should be clear systems in place to properly monitor and correct any mechanical integrity issues with clear deadlines and assigned personnel. Periodic hazard analyses and audits should also be completed to monitor mechanical integrity.

### Preventative Maintenance

Operational reliability is also composed of preventative maintenance, a key feature in the fishbone model. Preventative maintenance is the regularly performed monitoring of equipment for potential failure, and implementation of strategies to prevent the potential failure from occurring. Preventative maintenance is further defined as, “...planned maintenance that prolongs the lifespan of company assets, equipment, and infrastructure.” (16). Examples of preventative maintenance include repairing equipment, cleaning equipment, and monitoring, maintaining, or replacing aging equipment. Procedures for preventative maintenance are necessary to direct employees, and communication between front-line employees and supervision levels is also essential. The front-line operations employees typically work with machinery and equipment the most, becoming more familiar with the status and problems of said equipment; therefore, it is vital that front-line employees actively convey information and findings regarding preventative maintenance. A strict system needs to be in place to ensure preventative maintenance plans have a clear procedure, responsible persons, and schedule. A lack of enforcement of preventative maintenance plans can lead to catastrophe.

### Security

The last subsection under operational reliability is security. Security within an organization can best be described by security culture and implemented information security measures, both of which support one another. Information security measures include security policies set in place by the company, which are directly linked to the overall strategy of the company. The policies set in place should follow the mindset that, “anything can happen”. This includes proper physical security at plant sites (fencing, gates, ingress / egress checks), as well as potential cyber security impacts on the physical plant and operations. Furthermore, security measures consist of security procedures which can include user instructions, security plans, and non-disclosure agreements. To have effective security measures, procedures should be readily available to employees. In order to support and build a good security culture, it is necessary to implement security awareness training, security audits, and security related incident reporting systems (17). These measures put security management in the hands of the employees by giving them the necessary tools and information to actively practice and support site security. Additionally, security needs to be accounted for during transient operations and emergency situations.

## Engagement

The second bone under organizational culture is engagement. In order to ensure sustainable process and personnel safety, engagement is needed between all levels of a company. As changes occur within an organization, it is imperative that the different levels of leadership effectively communicate with each other and collaborate to adapt. Engagement with customers and the community is also necessary to keep an organization constantly aware of its surroundings, potential issues or concerns, and respond accordingly. When referring to engagement, BST states, “to achieve consistently excellent performance, there must be engagement in process safety at all levels. This is because the only way to change unwritten rules is through leadership, exhibited systematically and intentionally at all levels over a sustained period of time” (4).

### Internal and External Communication

The first subsection under the engagement bone is internal and external communication. Internal communication within leadership levels and among employees actively supports and encourages process safety as well. The use of metrics and monitoring, such as leading and lagging indicators, as well as regularly reviewing these metrics can be used to identify when a renewed focus on safety is required. By providing feedback between leadership levels, people stay informed and adjust to new, necessary changes. One additional component of internal communication includes the popular concept of “blue collar” versus “white collar” perspectives in the workplace. Marty Stern - the Global Director of EHS at Colgate-Palmolive Company - speaks on the importance of removing this divide and how it relates to safety, “There needs to be ongoing vigilance and connecting leadership to the floor. There’s a tendency to sit behind a computer and stay in the office, but you need to get out and connect to people on the floor- both technically and personally. How you connect with people is more important to a safety culture than any program. You need the personal connection” (18).

External communication is important for capturing new and evolving ideas. Broadly speaking the scope may entail other operations within one’s company, competitor / industry, as well as learning from other unrelated industries. This can lead to the acknowledgment and application of new safety measures. It is also important for conveying new measures and safety items to customers, government, and the community. Keeping these parties informed builds trust and builds a good safety reputation, necessities for supporting and developing an exemplary safety culture.

### Sense of Ownership

A sense of ownership exhibited by employees is essential to ensuring engagement. A sense of ownership over the functions and processes that occur within an organization is vital to supporting and maintaining excellent process safety. By developing a sense of ownership within a company’s employees, there is an enhanced sense of responsibility and control over process safety. BST describes the sense of ownership with regard to the actions of individuals, “employees understand the importance of these (and other) actions, feel that their immediate managers want these actions to occur, and feel supported in their work by their immediate managers and supervisors.” (4). Supporting and encouraging a sense of ownership can come from rewarding and recognizing employees that actively take actions to ensure process safety. Additionally, financial incentives may be another method for encouraging and supporting a sense of ownership of process safety although one recognizes potential pros and cons of such incentives.

### Visible and Felt Leadership

The last subsection under engagement is visible and felt leadership. Leaders at each level within a company have much influence over employees and other managers. Setting the tone for how the company should be run, supporting employees to act in a manner that aligns with the company vision and expectations, and challenging and collaborating with other levels of the organization is how leadership can be visible and felt within an organization. For senior executives, it is imperative to exhibit both symbolic and substantive leadership behaviors in order to support process safety. Examples of these behaviors include: regularly reviewing safety metrics, asking follow-up questions after incident reports, ensuring completion and effectiveness of action items, and asking for progress reports regarding safety-related goals. For mid-level managers, it is essential to adopt behaviors that support safe organizational functions. What these managers do and say can endorse or reject the unwritten rules that arise from company culture. Front-line employees’ essential tasks include reporting small process deviations, supporting one another when good safety practices are followed, helping fellow employees struggling with safety practices, and ensuring that actions supporting process safety are followed (4).

## Occupational Health and Safety

The last major bone in the fishbone model under organizational culture is occupational health and safety. This bone is made up of the safety management systems within a company in conjunction with auditing and assurance of safety measures. Employee caring, or employee health promotion, is another key feature of this area. It is vitally important to provide employees with resources to encourage healthy lifestyles, both in and outside of the workplace. Job safety analyses to account for and prevent potential hazards for specific jobs within an organization are also vitally important. Occupational health and safety is an important bone under organizational culture, clearly of equal weight as others.

### Safety Management Systems

The first subsection under the occupational health and safety bone is safety management systems. Safety management systems are the organization's approach to reduce hazards & risks and ensure preventative risk measures are effective. Good safety management systems include process risk assessment and analysis, compliance with process safety standards, process safety knowledge and competence, and implementation of good engineering practices (19). Management systems generally address the scope, procedure, responsible resources, related KPIs and means for improvement. These safety management systems, while generally composed of the same components, are tailored to a company based on the degree of risk and type of operations within an organization.

### Job Safety Analysis

The next subsection under the occupational health and safety bone is job safety analysis (JSA). JSA is going through each step of a process and identifying potential hazards. After identifying the hazard potential, measures should be taken to eliminate or reduce the risk. The four basic steps of JSAs are selecting the job to be analyzed, breaking down the job into a sequence of steps, identifying potential hazards, and determining preventative measures to overcome these hazards (20). There are many resources online that aid in job safety analysis, including breaking down the step by step procedures for this analysis and how to identify hazards for specific jobs. And like procedures, JSAs can be saved / cataloged for sharing, future use and improvement.

### Employee Health Promotion

This is essentially the actions a company takes to encourage health and safety for employees; it’s how an organization cares for the employees. It also involves the availability of resources for employees that are necessary to initiate progress towards safety and health related goals. Promoting employee health includes providing health insurance, return to work programs, sponsored health screenings, substance abuse, health and wellness activities, fatigue management, vaccinations, exercise support, and medical surveillance, to name a few (21). Actively supporting and promoting employee health shows how an organization cares about and for its employees, and often the caring goes both ways.

### Audit and Assurance

The final subsection under the occupational health and safety bone is audit and assurance. Procedures, protocols, and programs regarding personnel safety within an organization should be regularly reviewed, and employee evaluations should be conducted to ensure these procedures are being followed. Internal auditing in conjunction with external auditing is essential to recognize insufficient adoption of safety procedures and measures. In addition to identifying potential shortcomings, this also provides the opportunity to identify best practices for sharing with others and for the audit team to share their best (better) practices.

*A2. Incident Investigations:*

The following incidents provide insight on how shortcomings in organizational health can lead to disaster. The root causes of these incidents are all related to organizational health shortcomings, and this is shown through application of the fishbone model to their subsequent root causes. The root causes of these incidents were not determined as part of this study but were provided by reliable sources and outside research. These summaries are intended to provide real world examples of how organizational health can lead to safety incidents.

## NASA

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NASA has been under much scrutiny with regard to poor organizational culture due to: The Challenger Space Shuttle Disaster in 1986 and the Columbia Space Shuttle Disaster in 2003. In both of these incidents, one of the main root causes was top management prioritizing cost and schedule over safety. This led to self-censorship within the organization, further resulting in inaccurate information for decision making (22). By applying this root cause to the organizational health fishbone, it is apparent that many important features of organizational health were lacking within NASA. The ‘Company Vision’ subsection under ‘Policies’ appears to be lacking. Safety should not be compromised for cost or schedule. The entire ‘engagement’ bone appears to be lacking from the fishbone model as there seemed to be weak leadership, no sense of ownership, and limited internal communication. If employees are afraid to speak their minds with regard to potential for hazards because management holds the power, and track record, to undermine safety, then organization culture has severe shortcomings.

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## Upper Big Branch Mine Incident

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On April 5th, 2010, the Upper Big Branch Mine exploded, killing 29 miners. Results of an investigation conducted by the Mine Safety and Health Administration (MSHA) revealed that the root cause of this incident was poor organizational culture. Specifically, it was a pervasive culture that put production over safety. Management at this company reportedly did not comply with standards such as training employees. Management also failed to record hazard potentials, all the while intimidating employees to work in a mine lacking ventilation of explosive gases (23). Applying these root causes to the fishbone diagram, one finds that many sections were lacking. The ‘Industry Standards’ subsection, among others, under the ‘Policies’ bone is lacking. Management outwardly ignored industry standards in order to focus on production. The ‘Hazard Analysis’ subsection under the ‘Process Safety’ bone is severely deficient due to the company not recording potential hazards. In fact, the entire process safety bone is missing; this company reportedly did next to nothing to support their employees in terms of process safety. In addition, there are many other subsections that could be considered completely absent from this company’s fishbone.

## BP Texas City

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On March 23rd, 2005, the BP Texas City refinery experienced a disaster resulting in 15 deaths and more that 170 injuries. The Baker Report on the BP Texas City disaster cites many causes for this disaster, including a poor safety management system. It was determined that the safety management system lacked risk assessment and analysis, compliance with internal safety standards, process safety knowledge and competence, and process safety audits (19). These root causes fall under many of the fishbone sections such as the ‘Safety Management System’, the ‘Audit & Assurance’, the ‘Competence’, the ‘Operational Excellence’, and the ‘Design and Operability’, to name a few. The Baker Report also lists corporate safety culture as a root cause. It was determined that the company lacked process safety leadership, employee empowerment, process safety resources, and incorporation of process safety into management decision-making (19). These root causes fall under the fishbone sections such as, ‘Visible and Felt Leadership’, ‘Sense of Ownership’, ‘Utilization of Data’, and ‘Hazard Analysis’, to name a few.

## Bhopal Disaster

On December 3rd, 1984 a Union Carbide India Limited pesticide plant in Bhopal, India suffered a release of toxic methyl isocyanate which quickly dispersed over the densely populated community and nearby railway station. There were over 500,000 exposures to this deadly gas and thousands of immediate deaths. The main root cause of this catastrophe was determined to be lack of local safety culture which promoted employees’ distrust of management and the inability to instill a positive safety culture within the facility (24). This element falls under a few components of the fishbone model including all sections of the “Engagement” bone. The business lacked ‘Internal and External Communication’, a ‘Sense of Ownership’, and ‘Visible and Felt Leadership’. Without leadership effectively communicating their safety plans and culture, there was no sense of ownership from the employees to act in a safe manner. This root cause is also associated with a lack of ‘Company Vision’ and ‘Company Expectations’ as found under the ‘Policies’ bone.

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## A3. Definitions:

**Note:** *The terms defined in this appendix represent the results form a collaborative effort of the research team. Please recognize that these terms specifically apply to this paper, and these definitions represent safety-related terms from different sources.*

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| Consequence | The direct, undesirable result of an accident sequence usually involving a fire, explosion, or release of toxic material. Consequence descriptions may be qualitative or quantitative estimates of the effects of an accident. |
| Contractor | Person or company that undertakes a contract to provide materials or labor to perform a service or do a job at a company (not a fulltime employee). |
| Engagement | Workplace approach resulting in the right conditions for all members of an organization to give their best each day, committed to their organization's goals and values, motivated to contribute to organizational success. |
| Equipment | A piece of hardware which can be defined in terms of mechanical, electrical or instrumentation components contained within its boundaries. |
| Event | An occurrence involving a process that is caused by equipment performance or human action or by an occurrence external to the process. |
| Explosion | A release of energy that causes a pressure discontinuity or blast wave. |
| Failure | An unacceptable difference between expected and observed performance. |
| Fire | A combustion reaction accompanied by the evolution of heat, light and flame. |
| Fishbone Model | Cause-and-effect diagram that helps managers track down the reasons for imperfections, variations, defects, or failures. |
| Flammable | A gas that can burn with a flame if mixed with a gaseous oxidizer such as air or chlorine and then ignited. The term “flammable gas” includes vapors from flammable or combustible liquids above their flash points. |
| Hazard | An inherent chemical or physical characteristic that has the potential for  causing damage to people, property, or the environment. In this guide it is the combination of a hazardous material, an operating environment, and certain unplanned events that could result in an accident. |
| Incident | An event or series of events, resulting in one or more undesirable  consequences, such as harm to people, damage to the environment, or  asset/business losses. |
| Indicator | A measurement, especially a trend or fact, which provides information on the state or condition of something. |
| Lagging Indicator | An outcome-oriented, retrospective indicator measuring describing events that have already occurred and may indicate potential recurring issues. |
| Leadership | Upper management level of a company, including the “c-suite”, directors, managers, supervisors, etc. |
| Leading Indicator | A forward-looking indicator measuring the performance of the key work processes, operating discipline, or protection layers that prevent incidents. |
| Maturity Model | The measurement of the ability of an organization for continuous improvement in a particular discipline. |
| Metric | A method of measuring something, or the results obtained from the measurements. |
| Mitigation | Lessening the risk of an accident event sequence by acting on the source in a preventive way by reducing the likelihood of occurrence of the event, or in a protective way by reducing the magnitude of the event and/or the exposure of local persons or property. |
| Near Miss | An undesired event that under slightly different circumstances could have resulted in harm to people, damage to property, equipment or environment or loss of process. A challenge to a safety system, where challenges to a safety system can be divided into the following categories:  ● Demands on safety systems (pressure relief devices, safety instrumented systems, mechanical shutdown systems)  ● Primary containment inspection or testing results outside acceptable limits, or  ● Process deviation or excursion |
| Prevention | The process of eliminating or preventing the hazards or risks associated with a particular activity. Prevention is sometimes used to describe actions taken in advance to reduce the likelihood of an undesired event. |
| Process Safety Event | An event that is potentially catastrophic, i.e., an event involving the release/loss of containment of hazardous materials that can result in large scale health and environmental consequences. |
| Reliability | The probability that an item is able to perform a required function under stated conditions for a stated period of time or for a stated demand. |
| Risk | A measure of human injury, environmental damage, or economic loss in terms of both the incident likelihood and the magnitude of the loss or injury. |
| Shutdown | A process by which operations are brought to a safe and non-operating condition. |
| Sustainability | Industry, business, and environmental practices aimed at improving the long-term viability of business. |
| System | A collection of people, equipment and methods organized to accomplish a set of specific functions. |