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Understanding Process Variability to Improve Safe Behaviors

Achieving a desired safety culture in any organization is not easy and to suggest that there is some magic bullet that provides a quick and easy solution is futile at best. Every organization is dynamic in nature and has its own personality. Added to this is the reality that safety success is for the most **part**, determined by the customer and for most of us, our list of customers is long and varied with differing definitions of what success looks like. Parallel to this thought is that there is no "one right way" to achieving a desired safety culture, but a myriad of elements employed to build robustness within the safety process. Simply put, organizations that demonstrate world class performance on a daily basis employ a strategy filled with elements that control loss producing variation in the work system.

Controlling process variation is not a new concept. Many successful operational effectiveness programs have been built around the tenant that reducing variability and stabilizing the manufacturing process supports the objective of producing world-class results. This is supported by the ever increasing global movement toward *Lean Manufacturing and Six Sigma* concepts and is evident in almost all highly successful organizations.

Applying this thinking to building a desired safety culture, maybe the best question to ask is "can an organization leave so much variation within the work system that workers are leveraged to make poor decisions while performing their work?" It seems logical that in many incidents where a worker chose to perform an unsafe act, their decision to err was leveraged by other uncontrolled variables residing in the work system.

In the book, Human Error Reduction and Safety Management, Dan Peterson writes that "human error is involved in every accident and there are many reasons behind this behavior." Peterson goes on to say that "when incidents occur, it's the result of systems failure and human error." The worker who chooses to do an unsafe act is directly linked to the work system where he or she resides.

Philip Leather, in the book "Safety and Accidents in the Construction Industry," researched construction safety from a work-design perspective. His research suggests that a multi-factor approach to analysis is necessary to understand work system failure. He states, "the study of construction safety revealed a complex array of diverse, yet often closely interrelated, factors and relationships." He writes "a recurring obstacle to developing effective strategies for improving the industry's safety record has been its overriding acceptance of single-variable analysis, in particular, its preoccupation with the concept of carelessness as a unifactorial and unqualified explanation of accidents." Leather goes on to say, "what is needed is understanding and explanation, which emphasizes the multiplicity and complexity of accident causation, especially the interrelation of individual, organizational and job variables." There are certainly more factors to consider in determining why loss occurs in the workplace.

Several years ago, I investigated a workplace incident where a worker was killed while performing a work task on equipment that was not isolated from its energy sources. The investigation detailed that the worker reached into the equipment to clear a machine jam and while doing so, caused the equipment to move when the jammed product dislodged resulting in him being crushed in the equipment. As I reviewed the unfortunate event and analyzed the scene and the equipment involved, my reaction was simply Why? The hazards were clearly evident, the facility's energy-isolation procedure was complete and records indicated the employee had been sufficiently trained. On the surface, everything seemed to be in order but as I conducted employee interviews and reviewed past maintenance and downtime reports, planned inspections and training records, a new picture emerged…uncontrolled variability left in the work system created an environment that leveraged the employee to err. The employee was simply emulating behaviors of a work system that supported such risk taking.

Gaining control of the work system actually begins by understanding where such variability lies in the process. Understanding three terms help understand where and at what level such error resides:

- Latent Errors are errors in design, management decisions, organizational, training, or maintenance-related errors that lead to operator errors. The negative consequences of these mistakes often lie dormant in the system for long periods of time.

- Armed Errors are errors in position to affect persons, property or the process or a combination of all.

- Active Errors are errors made and the resultant effects realized. This usually occurs at the front-line by a worker with the effects felt almost immediately.

My investigation of the fatality revealed latent errors dating back years before the incident. The machine was poorly designed and inadequately guarded. Training had been performed and procedures written, but the capability development plan lacked a quantifiable method for measuring success. The preventive and reactive maintenance plan was weak and there was a lack of management discipline and control. The organization simply allowed too many variables (or latent errors) to reside in the work system creating a path for catastrophic loss when the engineer accepted the deviant errors as the norm (armed errors) and made the decision to err (active error) which cost him his life. This example also seems to confirm Deming's 85/15 rule that states that about 15% of a company's problems can be controlled by the employees, while 85% or more is controlled by the managing system. In other words, a vast majority of loss control problems are management problems.

To add more complexity, various government and independent research organizations continue to report that more than 90% of all incidents are caused by the unsafe acts or the active errors workers commit. Therefore, it would seem logical that if we fix the worker, we can fix the management system. From a systems safety perspective, we would consider such an approach as single point focus. Adapting to this thinking is dangerous because it most likely drives a management system toward trying to control the most fluid variable within the work system – the human variable. Herbert Heinrich, who pioneered the domino theory of accident causation, said that loss is sustained when a sequence of logical factors (dominoes) occur that results in injury. When a domino falls, so do the succeeding dominoes. By removing the domino that represents the unsafe act or conditions, an accident can be prevented. Frank E. Bird, a researcher with the International Loss Control Institute, recognized this issue in the early 1970s when he introduced a revision to Heinrich's domino theory and established a model that added management system error to the sequence of causation. The Heinrich and Bird Models are both illustrated in Figure 1.

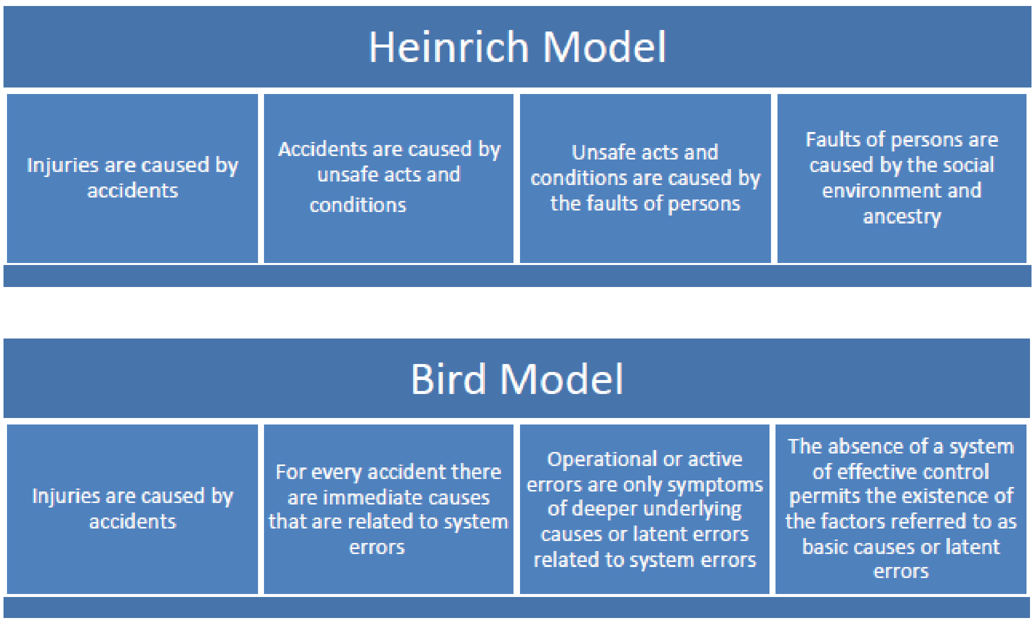

Figure 1. Heinrich/Bird Models

As my own experience and the data demonstrates, there is ample evidence to suggest that we need to view worker error as at-risk behavior performing in a management system that may be allowing too much variation to reside.

With the goal of improving safety performance and driving toward a desired safety culture, it's clear that we must first recognize that safety is part of a large, often complex work system combined of many parts. Important to understand is that when deviance occurs in one system, it is likely to have impact to the others. To mitigate such errors, a systems approach is warranted with the goal of building process robustness. Two practices widely utilized in Occupational Safety are Heinrich Model Injuries are caused by accidents are caused by unsafe acts and conditions Unsafe acts and conditions are caused by the faults of persons Faults of persons are caused by the social environment and ancestry Bird Model Injuries are caused by accidents For every accident there are immediate causes that are related to system errors Operational or active errors are only symptoms of deeper underlying causes or latent errors related to system errors The absence of a system of effective control permits the existence of the factors referred to as basic causes or latent errors Hierarchy of Controls and Inherent Safe Design. At a minimum, Hierarchy of Controls should fundamentally be an integral part any safety management system for establishing the order and magnitude of control in minimizing hazards within the work system. At the top of the "hierarchy" are controls that use design and engineering solutions to eliminate hazards, proceeding down to less desired solutions that leave the hazards in place, but use administrative control and personal protective equipment to control the hazards. Hierarchy of Controls is illustrated in Figure 2.

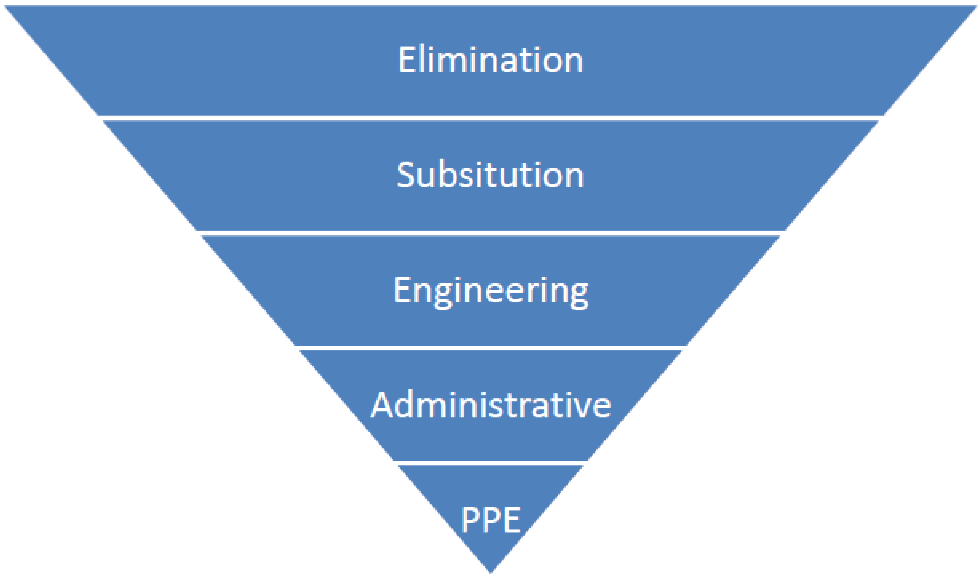

Figure 2. Hierarchy of Controls

Another approach to be considered alongside and often combined with the Hierarchy of Controls process is the concept of Inherent Safe Design that is utilized heavily by industries where OSHA's Process Safety Management standard (1910.119) is required. Though both methods parallel in some process considerations, deployment of Inherent Safe Design begins with a premise that perfect safety cannot be achieved by just the design features of the process and must extend throughout its life cycle. Specific to Inherent Safe Design is the finding of error-likely situations and building control through consequence and likelihood reduction. Inherent Safe Design concepts include the following key areas:

- Hazard Elimination: Eliminate hazards as a first priority rather than accepting them and mitigating them as a risk reduction strategy once they exist;

- Consequence Reduction: Where hazards cannot be completely eliminated, find less hazardous solutions to accomplish the same design objective by techniques such as reducing exposure to the hazard, reducing inventory of hazardous materials, and substitution of less hazardous materials; and Elimination Subsitution Engineering Administrative PPE

- Likelihood Reduction: Reduce the likelihood of events occurring by techniques such as simplification and clarity to lower the chance of an initiating event, and layers of protection and redundancy of safeguards to reduce the progression of an incident.

I have learnt that building and sustaining successful safety management processes hinges on building robustness in four key areas. Figure 3.

Figure 3. Safety System Factors

Reviewing Figure 3, we can now begin to understand that in order to control system variability and reduce loss; we must consider the work environment, the workers within that environment and their capability to do the work, organizational and employee behaviors, and management leadership as critical elements for success. While these factors are broad, they are interwoven within the organizations fabric and when change occurs to one, it generally results in change to the others. Using this logic, asking a worker to improve his or her behavior and work safely without providing guarded equipment and the necessary training introduces too much variability in the work system. Each element in the work system literally hinges on the success of the others. In my years as a safety manager at two large manufacturing facilities, one of the first things to emerge during trend analyses of past incidents was that few workers were actually injured while equipment ran true to its design. However, when operators were forced to intervene, the outcome was only as good as the workers' ability to avert potential incidents. During my time at both facilities, I identified "process upset" as a major variable in successfully controlling incidents and worked aggressively to get equipment manufacturers, engineers and process specialists involved to increase the reliability and efficiency of the equipment. My motivation was grounded in the Work Environment Behavior Leadership People belief that once an employee was working outside the defined control of the work system, he or she often drew reasonable, though potentially flawed conclusions that in some cases, would lead to loss.

In safety, just as in quality, variability within the system must be controlled to attain and sustain desired performance results. Though not an exhaustive list, Figure 4 illustrates possible variables within a work system. A majority of the list stems from the historical data of past accident investigations. Critical to understand is that variables are factors that intervene between the design of a system and the production process, resulting in conditions where errors are more likely to occur. Although good managerial decisions are required for safe and efficient production, they alone are insufficient. There is an equal need to properly maintain and ensure the reliability of the equipment; maintain a skilled and knowledgeable workforce through continuous training and engagement; establish reasonable work schedules and staffing as well mentoring and clear guidance on desired performance to achieve success.

Work Evironment	People	Behavior	Leadership
• Equipment	• Knowledge	• Mentoring	• Supporting
• Tools	• Skill	• Leading	• Communicating
• Procedures	• Training	• Coaching	• Discplining
• Purchasing	• Intelligence	• Following	• Recognizing
• Work Design	• Stress	• Accountibility	• Evaluating
• Engineering	• Motivation	• Expectation	• Analyzing
	• Hiring		• Creating Value

Figure 4. Safety System Variables

With that said, the question is how much variation can we allow in the work system and what are the critical variables to control? As a starting point:

- Review data from past safety incidents and near-miss reports, planned inspections, and maintenance logs. Benchmark similar industries to determine the latent errors that have allowed loss to enter the system(s) in the past. In this scenario, each incident is independent but common errors are most likely identifiable.

- Recognize the problems (errors) that need resolution and determine the level of threat to the system with regard to severity, frequency and the probability of reoccurrence.

- Identify where the problem (error) resides within the safety system to diagnose larger systemic issues.
  This includes the physical aspects, people, behavior, and leadership factors of the safety system.

Understanding the “mess” or the uncontrolled variables in the work system will likely paint a new picture showing where control is warranted. Continue down the path to:

- Determine probable solutions and consider the consequences of outcomes related to each proposed alternative.

- Promote solutions to your shareholders and gain endorsement. Implement changes to close variability (gaps) in the work system.

- Monitor for compliance; revise if needed to ensure success.

An example, again from my time as a facility safety manager— I started to notice a sharp increase in the number of hand lacerations occurring in the facility’s converting department. In a 12-month period, trend analysis showed that 72 percent of the injuries at the facility were caused by employees using utility razor knives. Further study indicated that employees used razors knives for more than 100 different tasks, wore no protection and had little training on knife use. There was also no uniform policy established or guidelines to govern razor knife use. As a result of this data, the facility changed its design and eliminated 98 percent of tasks requiring knives by tool substitution or process changes, implemented new policies and safety training, established mandatory hand protection requirements and switched to a safer knife design. Removing the uncontrolled variables in this case limited the number of active errors that occurred, resulting in the customer's desire of zero hand injuries. Since implementing this program in the 1990s, the facility has totally eliminated injuries resulting from razor knife use.

So can we as safety professionals, or better yet, as leaders leverage employees to make error free decisions? Clearly there is room for improvement in reducing risks that threaten safety success. Clearly more frequent use of methods employed to check work system status provides clarity of the current system. The challenge is not just gaining control of error producing variability already residing in the work system, but predicting where future variability will appear. Combine this with a work system that changes frequently and it's easy to understand that it would be impossible to prescribe the "one right way" to controlling variability in the work system. Maybe the best approach is to look at the safety system as a whole; that is not examining aspects in isolation but rather as collective. Through a better understanding of the entire work system, we can gain a clear understanding that while each element is independent, each is impacted and affects other parts of the overall system.

Leveraging the behavior of workers to perform to our desired expectations is simply recognizing that most of the variability in system performance is derived from the response of workers who have to function within a defined system, regardless of whether it's well-designed or not. The safe performance of the worker and their relationship to the environment is greatly influenced by its design and lifecycle. Overcoming resistance and gaining momentum for safety success is allowing little room to err by removing the system variables that would allow workers to make substandard – and sometimes catastrophic decisions.

"Quality is the degree of excellence at an acceptable price and the control of variability at an acceptable cost."

Robert A Broh

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