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Managing the Safety Consequences and Business Impacts of Construction Risk

An ioMosaic White Paper

Date: February 24, 2023

Executive Summary

Companies can have a process safety incident while performing construction, high risk or non-routine maintenance activities at their facilities, and the results can be devastating in terms of safety to the workers and public, the environment and the surrounding communities. There can also be significant financial costs to the company and /or contractors performing the work that can impact their ongoing ability to do business.

This paper examines the following aspects of this topic in order to help the reader find an effective solution to managing this risk:

- Why Construction Risk is Increasingly Important in Today's Environment
- Impacts of Construction Incidents Impact on a Company
- How Companies Historically Manage Construction Risk
- Drivers of Construction Risk
- The Solution to Managing Construction Risks
- Integrating CHA into your PSMS
- How to Get Started Managing your Construction Risk

Why Construction Risk is Increasingly Important in Today's Environment

Today's business environment is more complex than prior years making construction risk more important to manage than before. Incidents that may have gone unnoticed can now instantly become infamous and can draw the attention of different groups including community groups, regulators and special interest groups, with different priorities, including the potential delay or stopping of your project. Below is an example of one construction project that had fatal safety consequences and severe business impacts because those involved did not understand and effectively manage their construction risks.

Merrimack Valley MA, Gas construction incident – Sept 2018

On September 13, 2018, a series of fires and explosions occurred after high-pressure natural gas was released into a low-pressure natural gas distribution system in the Merrimack Valley part of Massachusetts. The pipeline was owned and operated by Columbia Gas of Ma, (CGM) a subsidiary of Nisource. The incident occurred during a construction project where CGM's contractor was upgrading gas piping from cast iron to polyethylene (plastic) piping. The cast iron main had incorrectly been isolated without first changing the gas regulators' sensing lines to the

new pipeline. This resulted in the pressure regulators going wide open and overpressuring the new plastic line which ultimately killed one person and injured 29 others. Fires and explosions damaged 131 structures, including 5 homes in Lawrence and North Andover, MA. The gas system design met the DOT 192 requirements for over pressure protection at the time of the incident.

Figure 1: Merrimack Valley MA, Gas construction incident – Sept 2018

Source: Wikipedia showing house damaged by a gas explosion in North Andover, MA 2018

The National Transportation Safety Board who investigated the incident identified 3 findings related to risk:

1. A comprehensive and formal risk assessment would have identified the human error that caused the redundant regulators to open and overpressurize the system.
2. Constructability review process was not sufficiently robust to detect the omission of a work order to relocate the sensing lines.
3. Engineering risk management processes were deficient.

Regulators in different industries are becoming more aware of available risk management techniques and are expecting businesses to manage their projects without any serious incidents. In the above example, after the incident, the Mass Dept of Public Utilities issued an order approving a settlement under which Columba Gas of Ma paid $56 million dollars for it role in the

explosion and had to transfer its gas distribution assets from Columbia Gas of Massachusetts to Eversource Energy.

After an incident like this, communities and special interest groups may start or increase advocacy efforts to stop this project and/or to prevent future projects. For companies that rely on expansion to maintain profitability, this can be a significant problem.

Recent years have also seen a growth in ESG (Environmental, Social Governance) scores that are used by some investment groups to rank a company. Process safety incidents are likely to lower a company's ESG score which can negatively impact their stock to certain investors.

Incidents like this can also make it more difficult for a company to get permits or licenses for new projects. Scrutiny levels increase and can increase the time and costs to get permits or regulatory approval for the desired project. Even though in the Merrimack Valley incident, the contractor performing the work made the final mistake in the field, there were systemic issues at the owner operator level so all parties involved were negatively impacted.

Process safety incidents can also increase a company's reputation risk and its share price volatility. After the BP Deepwater Horizon incident, BP's share price lost 54 percent on the NYSE between April 20, 2010, and June 25, 2010, bouncing back slightly before the wellhead was capped on July 15, 2010. BP stock lost a similar amount in London over the same period. Additional share price fluctuations occurred as financial costs for cleanup and settlement became available to the market.

Figure 2: BP Share Price Before and After Deepwater Horizon incident in 2010

Source: Yahoo Finance

Impacts of Construction Incidents Impact on a Company

"There's an old saying that if you think safety is expensive, try an accident. Accidents cost a lot of money. And, not only in damage to [the] plant and in claims for injury, but also in the loss of the company's reputation." —Trevor Kletz

Deepwater Horizon, Macondo Well Blowout in Gulf of Mexico incident – April, 2010

Control of a well off the coast of Louisiana in the Gulf of Mexico was lost during temporary well abandonment activities on the Deepwater Horizon drilling rig. This resulted in a blowout or uncontrolled release of hydrocarbons from the well which ignited. A series of technical, human, organizational and regulatory factors played a role in this incident. The explosions and fire led to the deaths of 11 individuals, serious physical injuries to 17 others, and the release of 4 million barrels of hydrocarbons into the Gulf of Mexico.

Figure 3: Deepwater Horizon, Macondo Well Blowout in Gulf of Mexico incident – April, 2010

Source: Chemical Safety Board Investigation Report Deepwater Horizon, Macondo Well Blowout Executive Summary April, 2016

The impact of a construction incident like this one on a company, is similar to the iceberg image used in safety literature. There are the very visible components above the water line and then there are those costs and impacts that are difficult to see at first but can be very significant to a company's continued ability to operate. Each of the major impacts is described below.

Figure 4: Safety Iceberg

Source: Wikipedia showing iceberg formation

Direct safety related costs are one of the most visible aspects of an incident. The loss of life and injuries to workers and nearby public exerts moral and ethical costs on a company in addition to significant financial costs.

Clean up and associated environmental remediation costs can be daunting. The most impactful example is the BP Macondo Gulf of Mexico incident mentioned above. The 4 million barrels of released hydrocarbons resulted in $21 billion in gov't economic and environmental claims.

Regulatory fines can be extensive, and regulators can be at the federal, state and local levels.

Depending on the extent of damage, your company may face ***business disruption costs***. If your construction project was near an existing operation, this can mean that not only is your new asset damaged and delayed, but your existing assets that were operational, are now damaged and out of service. You may face additional business disruption costs if the incident occurred near your inventories of raw materials or finished goods. Business disruption costs can cause companies to lose customers who have to go elsewhere for their needs which further strains cashflows and reduces operating profits.

Process and equipment rebuilding costs are also significant. The new assets you were installing were damaged or destroyed and will need to be replaced or repaired. All the long lead equipment

that you specified and waited to receive, now needs to be reordered, and you are at the back of the queue having to deal with potentially even longer lead times.

There can also be a variety *of* ***claims and settlements*** to be paid out to nearby property owners impacted by the incident. These may cover the rebuilding of their assets and their business disruption costs.

In the case of the Merrimack Valley incident, there was also the ***loss of license to operate*** their assets which eliminated future revenue streams from that operation.

Reputational costs can continue to grow while a firm addresses the issues following the incident. Throughout that entire period, your company may be the recipient of negative publicity and increased social media scrutiny which can impact your customer base, finances and even stock prices. This can impact your cost to borrow making future projects more expensive and potentially out of reach.

Incident investigation costs will vary from internal costs, to cover employees that have to take on operational responsibilities while others are investigating the incident, to expensive costs of hiring subject matter experts to perform independent investigations and analysis in order to identify the root cause(s) of the incident.

Increased ***legal fees, insurance costs*** from the incident plus higher future premiums also impact a company's ability to operate.

Additional less tangible costs can include *decreased* employee morale and productivity and increased difficulties in hiring new employees if individuals do not feel it is safe for them to work there.

How Companies Historically Manage Construction Risk

Historically companies have used a series of reactive or lagging indicators to evaluate safety and manage their construction risk. Some companies operate under the belief that if they hire a contractor to perform the construction or high-risk maintenance activity, that the contractor is responsible for anything that goes wrong and that they have transferred their risk to the contractor. That belief may last until their first major incident, and then it is too late.

A common step to managing construction risk is the use of historical safety performance to prescreen qualified bidders. A company's procurement team may request potential construction bidders to provide the last three years of OSHA lost time incidents, restricted work time rates and

their insurance experience modifiers. This can help to weed out the lowest safety performers from being able to bid on a job, but there are few weaknesses that need to be pointed out. OSHA lost time incident (LTI) and restricted work time incidents do not include fatalities, so a company can have a relatively low LTI rate and still have had multiple fatalities. More importantly, as we learned through the Deepwater Horizon incident, occupational or personal safety incidents do not provide insights on process safety performance. On the day of the blowout for example, several BP managers were on the Deepwater Horizon for a ceremony to congratulate the crew for seven years without an injury.

Some companies have added occupational and process safety requirements into bidding documents to evaluate bidders. This can include a contractor providing their views on what are the risks associated with the job and how they will prevent an incident from occurring. Contractors may also be required to submit a Health and Safety Plan (HASP). After many years of reviewing contractor safety plans, the author notes that contractors typically focus on occupational risks and the more common incidents that are likely to occur. These can be unfortunate incidents that lead to soft tissue injuries, permanent injuries or even up to a single fatality, but their assessments have not included process safety type incidents or considered worst case process safety consequences.

Companies who want to take an extra step may weight the safety performance part of the bid so that companies with a performance lower than a certain threshold are less likely or cannot be awarded the bid. This can be helpful, but it is limited as the safety performance is occupational safety and usually lagging data. Some companies can get an increased false sense of security thinking that they have hired the “most qualified bidder” when in reality they have hired the “lowest cost bidder.”

Companies may require contractors to follow their company’s contractor safety policy and procedures. This again is historically focused on personal safety and will require things like periodic safety tailgate meetings, housekeeping, safety training and possibly even daily pre job safety briefs. These are very helpful in preventing occupational safety incidents, but unless they are focused on process safety type risks, they will not be effective.

Some firms may go through the added effort of hiring an independent 3rd party safety professional for large projects. This can be helpful to a degree but with several caveats. Foremost is that the safety professional cannot report up to the contractor or through the Operating group hiring the contractor. When that is done, the safety person will have limited authority and power to effectively perform their role as their will be constant pressure of production vs safety within the same part of the business and production historically wins. The independent safety inspector needs to report up through the company’s safety dept or other

group that is independent of operations so that if a serious safety issue arises, it will get the attention it deserves even if it means stopping the construction or high-risk maintenance activity until the matter is resolved.

The second caveat is that the safety professional must also be knowledgeable in process safety in addition to personal safety. It is not always easy to find someone with both skill sets. Another problem with this approach is that the independent safety professional is only hired for very large jobs, and you can have process safety incidents on smaller jobs just as easily. It should also be pointed out that while having an onsite, qualified safety professional onsite will help, they will be limited in their abilities to prevent an incident unless a detailed construction risk assessment such as a construction hazard assessment (CHA) is performed to help them identify and understand what the risks are that need to be mitigated.

One other common historical approach to managing construction risk is to use more project management or to try to make it project management's responsibility to keep the site safe. This will not be effective. The project manager(s) is responsible for production and keeping the job on track and maybe even on budget. They will not have the independence and possibly the skillset to focus on safety.

Drivers of Construction Risk

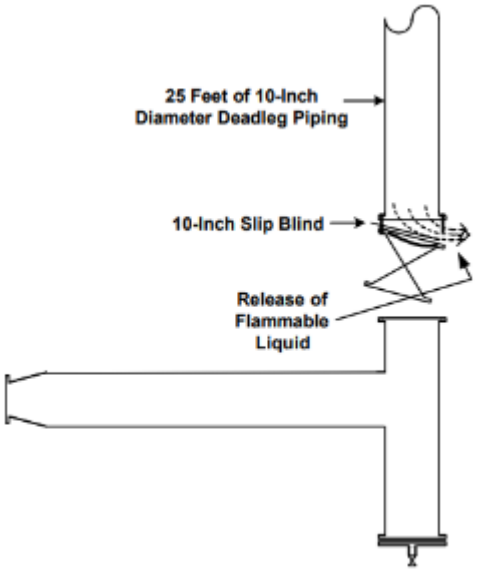
There are many drivers that increase a company's construction risk. Each of these drivers depending on how it is managed can increase or decrease a company's risk profile and either lead to or help prevent a process safety incident.

Production over safety value

If a company is focused on finishing projects on time and on budget no matter what the potential risks, then it values production over safety. When a senior leader comes to a job site and tells inhouse or contractor workers to work safe BUT finish on time, the part that gets the emphasis consciously or unconsciously, is the "finish on time." When a contractor pushes their employees to execute the critical crane lift even though winds are increasing and the forecast says it will get worse, they are valuing production over safety. Valuing production over safety is part of an overall poor safety culture. Safety culture takes a long time to build and requires constant nourishment to keep it going in the right direction. Without a positive safety culture, company employees will take unnecessary risks such as taking shortcuts or not following procedures which eventually will lead to an incident.

An example that illustrates this is the Bethlehem Steel's Burn Harbor mill incident that occurred in Indiana in 2001. Earlier in 1992, one of its furnaces was retired in place leaving its fuel gas system connected but valved off. Nine years later in 2001, the furnace was being demolished. Winter conditions and lack of insulation caused condensate drain lines to freeze leaving condensate in the gas piping. A leak was found on the gas line during the demolition work so plans were made to take the valve out before moving forward with the rest of the furnace retirement. This included installing a physical isolation with a drain line to be able to sample contents of the line. Unfortunately, the plans were changed as the plant wanted to perform the work quicker and cheaper, so a slip blind was installed instead of a blind flange and there was no longer a safe way to drain the line and remove the condensate liquids that had accumulated. As the bolts were loosened on the leaking valve flange, liquid condensate sprayed out, found an ignition source and engulfed two workers in flames, one of whom died. A supervisor fell from height trying to get away and died. Three other workers were injured running through the flames to escape.

Figure 5: Bethlehem Steel's Burn Harbor mill incident 2001



Source: CSB Investigation report on "Steel Manufacturing Incident", Jan 2002

Not understanding risk

Internal resources or contractors performing the work may not understand what risk is and more importantly may not understand how a company's risk appetite affects how they perform their activities. For example, if a contractor is working for a company that has a low-risk appetite,

meaning they do not want to take on any additional construction risk that can lead to a possible process safety incident, then the contractor should not push forward if uncertainty exists at the jobsite. A contractor that does understand their client's risk appetite on the other hand would call an immediate safety stop until the uncertainty is clarified, and work can continue safely.

An example of this type of driver is a contractor performing excavation work parallel to a live gas transmission line that occurred at a gas utility. The excavation equipment was fitted with a hydraulic impact tool to break rock and the operator positioned it so he could break rock near the live main, but that he could **not** see the parallel live gas main. The impact tool was set to automatic so that multiple impacts can occur faster. Unfortunately, the operator did not understand the potential risks of the impact tool sliding over the rock and striking the parallel high pressure gas pipeline. The result was that the gas pipeline was struck 8 times before the operator could react to stop it. Gas was released, but fortunately a rupture did not occur, and no one is injured.

Figure 6: Hydraulic impact tool

Source: ioMosaic Stock Image

Workforce competence

In operating and contractor companies, the workforce is changing. Older, more experienced workers are aging out and being replaced by perhaps more technically savvy workers. The downside is the newer workers lack the experience of performing safety critical tasks and often

have not had the benefit of learning from prior incidents and near misses. These workers lack the understanding of vulnerability that is important to preventing incidents.

An example of this is Donaldson Enterprises incident that occurred in Hawaii in 2011. Donaldson Enterprises had been hired to dispose of illegal fireworks. They were selected based on the "best overall value" even though they had no experience disposing of explosives. They had performed an incomplete risk assessment, made changes to it and then did not implement the safeguards that they had identified. The result was the explosives they were preparing for disposal ignited inside the storage area killing 5 workers and injuring 1 other.

Figure 7: Donaldson Enterprises incident 2011

Sources: CSB Investigation Report "DONALDSON ENTERPRISES, INC. FIREWORKS DISPOSAL EXPLOSION AND FIRE" January 2013

Resource allocation

As profit margins get leaner, companies performing construction and high-risk maintenance work may allocate less people or less hours to performing certain tasks. One of the most infamous examples of this is NASA leading up to the Columbia Space Shuttle incident in 2003 where 7 astronauts died due to a foam strike that should have been prevented. In 1994 NASA started cost cutting measures that removed 5,900 people from Shuttle workforce (13% of total). By 2000, the workforce was reduced by 25%. The head administrator of NASA's slogan was "faster, better, cheaper," and he believed that checks and balances were unnecessary. This eliminated a 2nd contractor whose role was to provide oversight to the design contractor and who theoretically

could have prevented the Columbia from lifting off based on the 65 prior foam strikes and near misses that had already occurred.

Figure 8: Columbia Shuttle Debris Field

View from Hewitt Texas

Debris was later found across 2000 square miles in Eastern Texas and in other states including California, New Mexico, Nevada and Louisiana.

Source: Columbia Accident Investigation Board report August 2003

Figure 9: Columbia Shuttle Launch January 2003

Source: Columbia before liftoff. Red circles are where foam later came off and where it eventually struck and penetrated the wing. Columbia Accident Investigation Board report August 2003

Non-qualified or high-risk sub-contractors

An Engineering Procurement Construction (EPC) contractor is often a way that companies can simplify and reduce overall project completion and cost risk. The company awards all the work from design through to construction to one EPC contractor. The EPC contractor is therefore the contractor that gets its safety performance reviewed and not necessarily the sub-contractors it hires to perform selected safety critical tasks. Tasks like rigging and crane operation for example are typically outsourced from the EPC contractor to a crane subcontractor. The sub-contractor is rarely evaluated from a safety performance.

Other examples of increased sub-contractor risks are when a sub is hired to perform a certain task but is not knowledgeable about other safety risks on the jobsite. One example is an excavation sub that was good at performing deep excavations but was not knowledgeable or qualified to work near gas pipelines. They did not understand the risk of not positively identifying all live gas pipelines before doing their work. The result was that gas transmission lines were struck in two locations in an urban area. Fortunately, the impacts did not penetrate the pipeline, and no one was injured.

Human factor errors

Human factor errors have led to many of the major construction incidents occurring in this country. Human factors is the relationship of a worker, their equipment and work methods, and their work environment. There are many points in this relationship that can break down and lead to a process safety incident. Examples of causes that lead to human factor incidents are noted below.

- Distraction
- Complacency
- Not understanding
- Overconfident
- Poor communication
- Lack of resources and teamwork
- Pressure to finish
- Poor decision making during operations
- Inadequate standards, procedures or administrative controls
- Fatigue

Any of these causes could lead to a worker not performing a critical construction task correctly, performing a task out of sequence, or working on the incorrect equipment which can lead to a process safety incident.

An example of multiple human factor errors that led to a process safety incident is the ExxonMobil Torrance Refinery explosion that occurred in Feb 2015 in California. The incident occurred when ExxonMobil was attempting to isolate equipment for maintenance, and preparations for the maintenance activity caused a pressure deviation that allowed hydrocarbons to backflow through the process and ignite in the electrostatic precipitator.

The CSB identified multiple weaknesses in ExxonMobil Torrance refinery's process safety management system that led to operating the unit without safe operating limits and criteria for unit shutdown, reliance on safeguards that could not be verified, degradation of a safety-critical safeguard, and the re-use of a prior procedure without a sufficient hazard analysis that confirmed it was still valid. This resulted in an explosion onsite with the release of dust to the nearby community. There were 4 injuries, and no one was killed from this incident.

Figure 10: ExxonMobil Torrance Refinery explosion Feb 2015

Source: Chemical Safety Board Investigation Report on "ExxonMobil Torrance Refinery Electrostatic Precipitator Explosion Torrance, California" May 2017

Equipment failures

Equipment that is not properly maintained or used outside of safe operating conditions can lead to very serious incidents.

Examples of this include some well-known crane failures that have occurred:

- Mecca crane collapse in Saudi Arabia's Grand Mosque in 2015. 107 people were killed and 230 injured.
- Turtle Bay Manhattan NY crane collapse in 2008 while constructing a skyscraper. 7 people were killed and 24 injured.
- Willow Island West Virginia crane failure in 1978. 51 workers were killed.

Figure 11: Cranes Similar to those used in Mecca, Saudi Arabia Incident 2015

Source: Wikipedia Mecca Crane Collapse

Equipment failures have the potential to increase in difficult financial times as some companies may be less willing or able to spend money on preventative maintenance, inspection, and testing.

Work Planning

Some companies have the philosophy that the foreperson in the job will plan and execute the job just before that part of the work takes place. That can lead to unknown risks of simultaneous

operations when 2 or more contractors are working in the same facility. An example of that is the Evergreen Packaging Paper Mill Fire that occurred in NC in 2020.

Figure 12: Evergreen Packaging Paper Mill Fire in NC 2020

Source: Chemical Safety Board Report on "Fire During Hot Work at Evergreen Packaging Paper Mill" Sept, 2021.

The Paper Mill was using 2 different contractors to perform maintenance in 2 separate but connected towers. The facility had a hot work process and required contractors to have safety policies and training but did not do a risk assessment to understand potential constructions risks. When Contractor A workers could not get the fiberglass and resin, they were applying in tower 1 to harden, they used a heat gun which they did not think was an ignition source causing a fire in their tower. They escaped, but the smoke travelled rapidly to the connected tower killing the 2 workers inside it. The Chemical Safety Board (CSB) indicated that effective pre job planning such as how to deal with resins in cold temperature and working safely in confined spaces could have prevented this incident.

Stranded assets retired in place

Facilities often retire assets in place, instead of paying the costs to physically disconnect it, make it safe for disposal and then dismantle it. This leads to assets that remain on a facility with possibly a single isolation valve separating it from equipment that is in service. The single valve can leak over time and result in a fire or explosion at the facility.

Another risk from retiring an asset in place is that workers who were knowledgeable about how that asset operated, and the risks associated with it are usually retired by the time asset is physically retired. This leads to people having to estimate how it used to work and what hazards, if any, remain.

An example of this is Midland Resource Recovery incidents that occurred in West Virginia in May and June of 2017 and resulted in the deaths of 3 workers.

Figure 13: Midland Resource Recovery incidents in West Virginia 2017

Source: Chemical Safety Board "Tank Explosions at Midland Resource Recovery" report Dec 2019

Midland Resource Recovery would collect, treat and dispose of obsolete gas odorizer equipment that it obtained from other companies. In May 2017 they were in the process of draining one odorizer when the top of it exploded killing the worker and severely injuring one other. Debris flew 500 feet in the air. CSB arrived after the incident to begin its investigation, but the company continued its operations. The 2nd incident occurred while CSB was still onsite killing the contractor performing the cleaning. Both times, the contractor did not understand the potential risks of mixing their cleaning materials with the contents of the tanks.

Unsafe work practices

A company or contractor may have employees that follow their own work methods, but if their work methods are high risk or flawed, then the risk still remains. Safety critical work practices or methods need to be evaluated from a process safety perspective before used at your job site, else you run the risk of having a process safety incident. The risk evaluation will help you understand what can go wrong by executing the procedure.

On Sunday, February 7, 2010, Kleen Energy, a combined-cycle1 natural gas-fueled power plant under construction in Middletown, Connecticut, experienced a catastrophic natural gas explosion that killed six and injured at least 50. This occurred while crews performed a cleaning of the new gas piping with flammable natural gas. The gas was forced through the piping by workers at high pressures (650 psig) and volumes in an attempt to remove any debris that had collected in the piping during the fabrication process. The morning of the event over 2 million standard cubic feet of nature gas had been released to atmosphere. The release point was oriented horizontally in a congested area between 2 large structures on the site, and there were numerous ignition sources in the area including welders, heaters, electric power and static charges from the gas venting.

Figure 14: Kleen Energy Conn 2010

Source: Wikipedia Kleen Energy incident Feb 2010

The Solution to Managing Construction Risks

The solution to effectively managing your construction risk is to perform the appropriate type of risk assessment so that you can identify your risks, decide which are within your company's risk appetite, and which risks you need to mitigate BEFORE construction work is started. This process is called a Construction Hazard Analysis or CHA. Using the CHA process levels the playing field against these other risk drivers as it will identify the various potential risks in an activity and give you the owner the opportunity to manage the risk before work is initiated.

A CHA is an organized, systematic approach to identify potential hazards and hazard scenarios that can occur at your jobsite. It is designed to be used when working on or near process safety

or other high-risk assets that if they fail can result in process safety type consequences such as fires, explosions, release of toxins, and have severe safety, environmental and business disruption consequences.

The purpose of a CHA is to help you prevent process safety incidents by understanding your potential hazard scenarios in advance of performing the work and give you the opportunity to add additional safeguards that will prevent or mitigate consequences or to change the work method to eliminate the potential hazard scenario.

The CHA is similar to a PHA (Process Hazard Analysis) in that it is a team-based approach led by a trained and experienced team leader and having team members that represent the workforce performing the work, those owning and operating the assets, and other subject matter experts such as process safety professionals and maintenance personnel. The team members and size of the team will vary with the complexity of the project.

The CHA starts with examining each phase of work and the activities to be performed. This is done using ioMosaic's PHA Global software package. Any activities that have the potential to result in a process safety consequence are risk evaluated. This means that the team leader will discuss with the team the various types of causes that cause a hazard scenario and process safety consequence to occur. Causes include the same three major types evaluated in a PHA: equipment failures, human factor causes and external events.

Once the particular cause and hazard scenario are understood by the team, the CHA Team Leader will work with the team to identify what are the current independent safeguards that will prevent or mitigate the hazard scenario. The team then risk ranks the scenario by identifying the worst-case potential severity of the scenario and the likelihood of that scenario occurring with the current safeguards in place.

This is the value point. Here is where the company can see how much risk they are taking on for each scenario. If the scenario's risk is above their risk appetite, or how much risk they are willing to take, then they can add an action item for the workforce to add another safeguard(s) to further decrease the severity or likelihood of the scenario occurring or to change the work method to lower the risk. Safeguards will be based upon the specific work being performed and the location of the work as both those factors will impact the risk.

This process is repeated for each activity until the causes and hazard scenarios that can result in process safety consequences are identified and risk evaluated.

Integrating CHA into your PSMS

In order to gain the most value from your CHA, it is recommended to integrate it into your overall Process Safety Management System (PSMS). This then becomes part of the company's day to day activities and ensures that CHAs are routinely added into future project plans.

Additional benefits of integrating the CHA process into your PSMS are listed below.

- *Hazard identification and risk assessment* processes are used across the life of a process safety asset and not just during design and management of change activities to enable a company to maintain its risk appetite.
- *Management of change* processes will apply to a CHA so that if the work scope or work method changes after the CHA is done, the change will have to be re-evaluated prior to beginning that part of the work.
- *Action items* from construction and high-risk maintenance jobs are managed on a risk priority manner similar to other process safety action items and can be tracked to completion.
- *Pre-Startup Safety Reviews* (PSSRs) can be used to ensure that PHA, CHA and relevant action items are completed before placing the asset into service.
- *Stakeholder outreach* can be applied if the consequences has the potential to impact offsite areas and needs to be coordinated.
- *Contractor management* practices can be included in the CHA process.
- *Emergency response plans* including onsite and offsite evacuation plans can be developed if necessary to mitigate consequences by being able to quickly move people away from a potential hazard scenario.
- *Learning from incidents* can be shared across construction activities and with contractors to prevent repeating incidents others at the facility or in industry have realized.
- *Management review and auditing* processes can be applied to CHAs to help continually improve the process before an incident occurs.
- *Leading and lagging key performance indicators* can be applied to the CHA process and added to the overall PSMS scorecard to find and resolve weak spots before an incident occurs.

How to Get Started Managing your Construction Risk

ioMosaic offers you several ways to start managing your construction risk.

- ioMosaic has trained and experienced team leaders that can work with your team and lead your CHA providing an overall CHA report from PHA Global.
- ioMosaic can help you develop and implement your own CHA process within your organization so that it is fully integrated into your Process Safety Management System.
- ioMosaic can provide initial and refresher training for your people to eventually be able to lead their own CHAs. This can be customized to meet your needs including onsite and offsite mentoring and partnering in leading the CHA until they are comfortable performing the process themselves

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