CHUBB®

Facility Maintenance Operations

(Turnarounds, Shutdowns and Outages)

Construction Risk Engineering

Contents

Processing or production facilities, such as Petrochemical Plants, Oil & Gas Refineries, Power Generation Stations, and Industrial Manufacturing Facilities (paper, processed foods, automobiles etc.), involve many operations performed during the typical production and distribution of the facility's products. These operations turn a feedstock into the final product for the consumer.

In addition, there are some operations that must take place outside of, but fully integrated into, production scheduling that are essential for all production to occur – Facility Maintenance operations and Capital Improvement projects. Maintenance and capital improvements are routinely performed to support production so that expected production levels can be maintained and to ensure and improve product quality, plant efficiency and equipment condition, as well as to expand facilities to accommodate increased levels of production, incorporate new technologies and increase capabilities.

Depending on workload, scope of maintenance activities, ability to perform work efficiently and/or availability of personnel in-house, plant maintenance activities may be completed by in-house personnel, contracted to maintenance firms or a combination of both. Regardless of approach, safety and quality must meet the same minimum standards and criteria to ensure a consistent and efficient operation.

If routine maintenance is not planned, scheduled and completed within allowable and acceptable timeframes, the equipment and related process and operations will begin to break down and eventually become inoperable, resulting in partial or complete stoppage of production. Also, if larger-scale capital improvements are not undertaken to retrofit processes and equipment or to expand overall production capacity and capability, a facility may no longer be able to compete within the industry.

Although each industry has its own inherent processes, techniques, equipment, safety and quality exposures, there are many similar exposures as well. Regardless of the exposures, steps must be taken to ensure that all maintenance operations and any capital improvement projects are implemented with care, proper planning, stringent safety and quality measures incorporated into the process, and that a pro-active safety culture is created and maintained for all involved.

If safety and quality are not fully integrated into maintenance and capital improvement projects, the safety of workers and surrounding communities can be directly affected. Lack of a proactive and fully integrated safety culture and quality assurance and quality control programs can result in worker accidents, equipment breakdowns and potentially catastrophic failures.

It is critical that project management within the plants/facilities do not treat turnarounds, shutdowns or outages as Engineering, Procurement and Construction (EPC/Capital Improvement) projects.

Types of Maintenance Operations

[1]Process industries, such as refining, petrochemical, power generation, pulp and paper, etc., perform maintenance operations and, in some cases, utilize maintenance wrap-up insurance programs for their facilities.

It is critical that project management within the plants/facilities do not treat turnarounds, shutdowns or outages as Engineering, Procurement and Construction (EPC/Capital Improvement) projects. Their project management methods differ, with each having their own specific needs.

It is also very important that operations and maintenance departments have a workable system in place that allows both the ability to work closely together to best coordinate maintenance and production operation scheduling, as each is mutually dependent on the other to achieve their goals.

Equipment reliability is directly related to proactive, scheduled maintenance work. There are many maintenance activities that can take place, including:

- Preventive maintenance – i.e., lubrication, filtration, alignment, cleaning and inspection and repair
- More advanced predictive activities, such as vibration analysis and inspections and equipment overhaul and replacement
- Continuous improvement of equipment and practices to enhance efficiency and performance.

Un-scheduled maintenance activities can be the result of equipment breakdown and the need for corrective maintenance to bring it back online.

Although terms used to describe scheduled maintenance operations may vary depending on the industry, the definition remains virtually the same for the most part and in many cases can be used interchangeably.[1]

Turnaround/Shutdown/Outage
A turnaround, shutdown or outage is a scheduled or unscheduled single or series of maintenance events for a facility/plant. An outage is generally a turnaround/shutdown that affects specific operating units and/or processes or the entire facility for an extended period. Turnarounds, shutdowns or outages can involve both critical- and noncritical-path items and range from days to several weeks. Turnarounds, shutdowns or outages can become, and in many cases are, the largest, most costly and complicated events utilizing maintenance resources. If the maintenance event causes a reduction in production, it is considered a turnaround, shutdown or outage.[1]

During a turnaround/shutdown/outage, facility/plant systems, equipment and – depending on the scale of the work to be completed – some major production units may be taken out of service. Due to the affect on production output, maintenance activities like these must be pre-planned and completed within pre-determine timeframes. The production will continue but at a reduced rate while the work is being completed, however this is taken into account when calculating overall production output for that operation, as long as the maintenance and/or capital improvements are completed and the production operation is back on-line as planned.[1]

Keeping on plan and schedule is critical during turnarounds, shutdowns and outages and can be complicated by a number of issues, such as unforeseen repairs and add-on work that, although may not have been contemplated in the original scope, must still be completed within the planned maintenance event without compromising plant and worker safety or quality.[1]

Maintenance vs. Capital Improvement (EPC) Projects

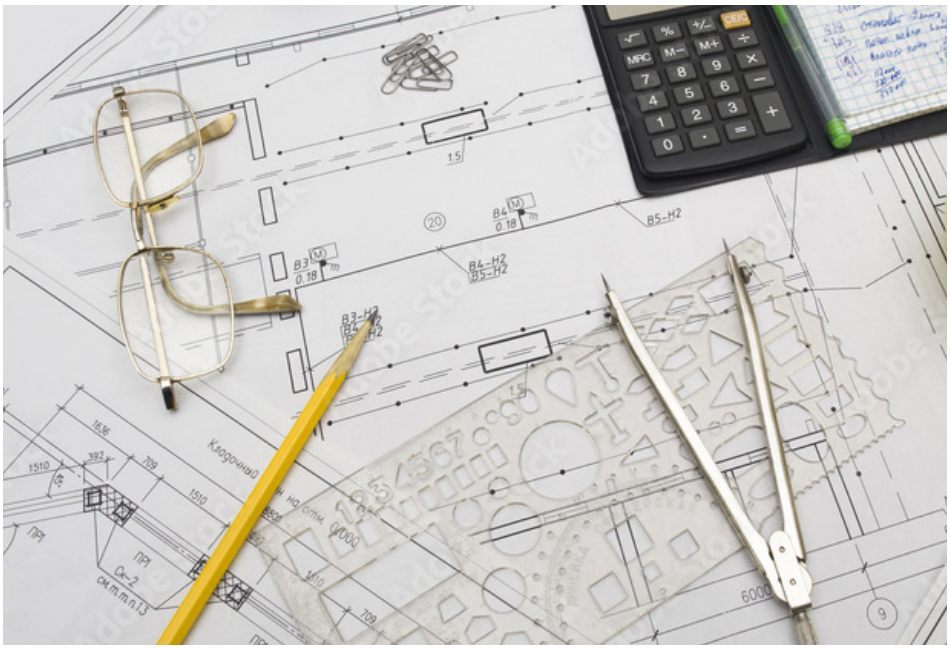
Capital Improvements
Although not the focal point of this Resource Guide, it is important that capital improvement projects are defined and how they may interrelate with maintenance activities is understood.

Although not a maintenance activity, many capital improvement projects may be included as planned and covered construction projects within a maintenance wrap-up insurance program. Whether or not the projects are also included in the same insurance program as the maintenance operations, these construction projects may be taking place at the same time as maintenance activities and in some cases may be interrelated.

Capital improvement projects are typically a much larger investment by the facility owner intended to expand the size, capacity and capability of the facility and add increased value to the overall facility. For example, the owner of a Petroleum refinery may choose to expand its capacity, or the owner of a power plant may choose to retrofit existing systems and equipment with newer, more advanced and efficient designs.

There are significant differences between maintenance operations and capital improvement projects.

- During maintenance activities, the scope is only partially known when execution begins, as a result, managing these activities demands much stricter scope and safety management controls.
  - It is common for maintenance activity scopes to be changing up to the last minute before project execution due to the use of the inspect and repair method. Because of this changing environment, project and contractor management must be diligent in their safety and quality practices so as not to let pre-planning, PPE, appropriate engineering or administrative controls and other established policies and procedures be set aside and not properly implemented or enforced.
- Capital improvement projects usually have a well-defined scope established with a long lead time before project execution begins.[1]



A constantly changing scope (and schedule) means that baseline schedules are virtually useless measuring sticks for maintenance activities. Unlike the baseline schedule, which is used as the basis for measuring and tracking Capital Improvement project performance, maintenance activities require a different methodology.[1]

While changing schedules and manpower staffing requirements make resource leveling a popular tool for capital improvement projects, it is counter-productive for turnarounds, shutdowns and outages. The compressed work basis for executing maintenance activities means that all team members have less time to analyze (pre-plan) and react to changing priorities or hazardous conditions.[1]

Problems that go unchecked or changing conditions that are not properly analyzed for health and safety concerns can significantly impact the chances for reaching "zero accident" milestones or time and budget goals. As a result, there is a much greater need for using the schedule to drive the project execution during maintenance activities, whereas it is sometimes used as a contractual tool in capital improvement projects. It is critical for all schedule and progress information to be highly visible, timely, comprehensive and accurate. This will allow for efficient execution of not only maintenance work but also safety and health activities.[1]

Industries Performing Maintenance Operations (typical)
There are many types of plants and facilities that require routine maintenance operations as well as the need to contract with others to perform larger-scale capital improvement projects for the expansion or retrofit of the facilities. The industries noted below are but a few of the common types associated with maintenance wrap-up insurance programs.

Petrochemical Industry
Petrochemical substances are used throughout industry. Once considered a waste product used for fuels, today they are manufactured into carbon

black, synthetic rubber, polystyrene, polypropylene, and polyethylene. Petrochemicals are widely used in agriculture, the manufacture of plastics, synthetic fibers, explosives, and in the aircraft and automobile industries.

Refineries
Oil and gas (petroleum) refineries are large complex facilities/plants where through the refining process, crude oil is turned into other petroleum-based products, such as gasoline, diesel fuel, asphalt base, heating oil, kerosene, and liquefied petroleum gas. The refining process requires the use of chemicals such as gasoline additives, oxygenates, caustics, sulfuric acid and hydrofluoric acid which need to be handled with care.

Power Generation
Electrical power is generated in many different ways:

- **Nuclear** – Nuclear fission is used within specialized containment to create heat which in turn creates the steam to drive electrical turbines.
- **Coal Fired** - Coal is burned to create heat which is in turn used to convert water into steam. The water vapor is pressurized and pushed through turbines, which causes the turbines to rotate creating the energy.
- **Combined Cycle** – These are plants in which the turbines are driven by steam and natural gas. The power is generated by the gas driven turbine, and the resulting heat created is in turn used to create steam to also generate electricity.
- **Hydroelectric** – These types of generating facilities produce electrical power through the force of water falling or flowing through turbines that turn the generators. It is the most commonly used form of energy production. Water is utilized to generate power in several ways – through dams by funneling water through a "penstock" or long tube, through the rise and fall of the tide, through pumped water from a storage location, and through the natural flow of a river.

Food Processing
Food processing is a series of processes, methods, specialized and sometimes proprietary (trade secret) techniques used to make different types of foods and food products. Food processing occurs in facilities that are maintained in a regulated state of cleanliness and that utilize specialized equipment that takes harvested crops and animal products and produces the food.

Manufacturing - Industrial Paper Plants
This is the process of turning plant, or more commonly tree, fibers into paper-based products through a series of processes. The process begins with debarking and chipping the selected trees. The wood chips are processed in large vats called digesters. Within the vats, chemicals are added to break down the wood chips into pulp. From there the pulp is further processed (beaten) in a large tub where other chemicals and colors are added. Once beaten, the pulp is filtered and sent through a series of rollers and presses
to strain and dry the pulp into long thin sheets (paper), which are stored in large rolls for shipping.

What should not be overlooked and can play a major role in how hazards and exposures occur and develop is the workforce itself.

Exposures Encountered During Maintenance Operations

People

While this document contains information regarding many hazards and exposures known to be prevalent during maintenance and turnaround activities, what should not be overlooked and can play a major role in how hazards and exposures occur and develop is the workforce itself.

The workforce can contribute factors that result in whether or not injuries or property damage occur. The workforce is made up of many types of workers, such as the young and old, male and female, the physically fit or the out of shape, the experienced and inexperienced, the physically able or those injured/restricted due to previous injuries.

Risk managers and safety professionals must be aware of and take into consideration the different attributes above that can affect a worker's ability to perform assigned tasks. These considerations, once evaluated, may result in the need for additional training programs, such as stretch-and-flex or proper lifting techniques, as well as the need to institute alternative duty assignments for workers determined by risk management and safety teams in needing to be limited in what their assigned tasks require them to do. "Fit for Duty" programs can be a major asset to the successful and timely completion of assigned tasks and are a pre-qualification requirement at some facilities.

For example, a stretch and flex program can be beneficial to all workers, especially those who may be out of shape and do not regularly exercise, and alternative job assignments may be beneficial for workers no longer having the capacity or dexterity to routinely climb large ladders or scaffolding. The alternative assignment process can be implemented so those identified workers are assigned only to tasks that limit their need to climb but still allow them to effectively perform and contribute to the activities taking place.

Restricted Work Areas

In many cases, maintenance activities are completed in locations where, due to the many different process units, vessels, piping, control systems and other facility equipment, working areas can be restricted and confined.

Depending on the level of maintenance activities taking place, the number of workers can range from two or three to several hundred or more in a relatively confined area. In these situations, being able to perform maintenance activities, such as welding, installing piping, setting up and tearing down scaffolding, and equipment removal and replacement, can become difficult and require diligent coordination and pre-planning.

All work areas should be visited and assessed prior to the start of activities. The work location should be observed and planned out, taking into account any restraints, such as the following:

- Access to and within the work area
- Equipment removal requirements (cranes, hoists, jacks, stands, etc.)
- Any specialized equipment or devices needed and the space available to set up and utilize them
- Multiple trades required to work simultaneously to complete their assigned tasks
- Proximity of other on-going or upcoming maintenance or facility operations
- Safety and environmental concerns and related equipment, including general and task-specific Personal Protective Equipment (PPE)
- Task and process unit-specific training requirements.

Only trained, authorized workers should be allowed entry into identified hazardous areas and areas where maintenance activities are taking place. During maintenance operations, plant conditions

Safe work practices should be trained and utilized to protect workers and the equipment.

can be different than during typical production. This is also true of outside contractors and workers who have not been properly trained to recognize plant-specific process safety hazards or other issues in the facility.

Barricades, signs, fencing and other means of segregating plant operations workers from those involved in the maintenance activities should be evaluated and utilized where necessary and possible.

Nuclear

In nuclear generating stations (NGS), maintenance workers are provided with specific training as required under the operating licenses issued by the U.S. Nuclear Regulatory Commission. This training explains the various components of time, distance and shielding to the workers to minimize radiation exposures while performing maintenance types of work. It also covers what radiation exposures are present to the workers in the area where work will be performed and how to avoid or minimize radiation exposures to themselves while performing various types of maintenance pertaining to nuclear reactor power plant programs. These training programs are provided to workers prior to starting work along with a fitness for duty evaluation.

Access to areas inside the NGS structures and plant yard areas is regulated and controlled by posting of radiation signs, control of personnel and the use of alarms and locks to minimize radiation exposures. Plant areas are categorized into radiation zones according to design basis radiation levels and anticipated personnel occupancy with consideration given toward monitoring personnel exposures as low as reasonably achievable (ALARA) and within the standards of Title 10, CFR part 20. Workers are provided with thermoluminescent dosimetry along with audible radiation monitoring to ensure that the ALARA program is being fully implemented as required.

Electrical

Electrocution

There are many electrical hazards that workers may encounter during routine maintenance operations or larger scale turnarounds. Electrical hazards can be found from motor control systems, generators, power and controls, conveyors, or other electrically powered devices. Regardless, safe work practices should be trained and utilized to protect workers and the equipment.

There are various ways to protect workers:

- Administrative controls (permits, work coordination, pre-planning/hazard analysis, safe work practices, warning signs and labels, training, etc.)
- Engineering controls (de-energizing the circuit, lockout/tagout, protective barriers/guarding, GFCI/Over current protection, etc.)
- PPE (according to NFPA 70E, Standard for Electrical Safety in the Workplace)

NFPA 70E Standard for Electrical Safety in the Workplace provides requirements for safe work practices to protect personnel by reducing exposure to major electrical hazards. Originally developed at OSHA's request, NFPA 70E helps companies and employees avoid workplace injuries and fatalities due to shock, electrocution, arc flash, and arc blast, and assists in complying with OSHA 1910 Subpart S and OSHA 1926 Subpart K.

Due to the potential for changing environments during maintenance operations, it is very important that when conditions do change (i.e., in the work area, tasks to be performed, timeframe allowed for the activities to take place), the employees are kept informed. If a Job Safety Task Analysis (JSTA) or like document was completed related to the original hazards, exposures and controls, it should be revisited and revised to reflect any changes and reviewed again with all affected workers.

It is essential that a formalized, written lockout/tagout system is fully implemented and that ALL employees, not just the contract workers, are fully trained in its procedures.

Workers should not be authorized to perform maintenance operations on "live" electrical components or systems, except only as a last resort when no other safer or practical means is possible. If work on live electrical components or systems is authorized, the operation should require the use of an approved written working permit and the operation should have a completed hazard analysis performed, all workers affected are properly trained, and the hazard analysis is reviewed.

Arc Flash

An arc flash occurs when an electric current passes through the air or short circuits between conductors. In an arc flash, there is extreme heat and pressure generated and the possibility of explosion. Temperatures from an arc flash have been known to reach or exceed 30,000 °F. As a result of the arc, metal, such as copper, is vaporized and pushed out away from the flash.

The heat, pressure and explosions created by an arc flash can cause severe injuries and burns to the skin, throat and lungs as well as other exposed parts of the body. Injuries can be minor to severe, including burns, infection and death, depending on factors such as location, distance and how long the worker is exposed to the arc flash.

If the arc is contained, for example in an electrical box, switch gear housing, etc., the pressure can be multiplied. If an arc flash occurs in a facility, it can be devastating, potentially setting off a chain of explosions and fires to chemicals, fuel gases, process systems and vessels and other vital processes within the plant/facility.

To control the potential for an arc flash, when work is performed within reaching distance of exposed energized parts of equipment, it is necessary to ensure that employees remove all exposed conductive articles, such as keys, chains, rings, wrist watches or bands. Only trained and authorized workers should be tasked with performing electrical work.

NFPA 70E, Standard for Electrical Safety in the Workplace was written to provide guidelines regarding arc flash prevention, PPE, protective clothing as well as for clothing worn while performing electrical work.

- NFPA 70E, Standard for Electrical Safety in the Workplace should be followed.
- Workers should not be allowed to wear clothing that when exposed to flames or electric arcs, could increase the extent of potential injury as a result.
- Electrical work on "live" electrical systems/components should be avoided whenever possible. Systems should be de-energized and properly locked out and tagged out until installations are completed.
- Workers are provided with and required to use PPE specifically designed for working on or around electrical systems, installations and components and appropriate for the type of work/voltages involved in the task.

Lockout/Tagout

Lockout and tagout is among the most common safety procedures encountered in a facility/plant (OSHA 1910.147 General Industry and 1926.417 Construction standards, respectively). Because of the routine maintenance and repair of the operations, production system equipment and power sources, there is always the need to isolate system components and energy sources to complete maintenance and other servicing activities.

Lockout/tagout is a procedure to help ensure the safety of workers who perform maintenance or repairs on equipment, machinery, electrical systems, valve assemblies or other devices that contain sources of energy or components that can unexpectedly be energized or released, causing serious injury or death.

A lockout/tagout system establishes a program and utilizes procedures for affixing specialized lockout and tagout

devices to energy isolating devices, and for disabling machines or equipment to prevent the unexpected startup or release of stored energy that could injury employees. The locks and tags are affixed only by those who will be performing the maintenance or repairs. These locks and tags are not removed until the repairs or maintenance are completed. Each separate party performing maintenance or repairs affixes their own separate lock and tag, each with their own keys, to prevent any single party from removing the locks and tags without the other parties' knowledge or approval.

It is essential that a formalized, written lockout/tagout system is fully implemented and that ALL employees, not just the contract workers, are fully trained in its procedures.

Confined Space

A confined space is a space that is large enough and configured so that an employee can enter and perform assigned work, has limited or restricted means for entry or exit (for example, tanks, vessels, silos, storage bins, hoppers, vaults, and pits are spaces that may have limited means of entry) and is not designed for continuous employee occupancy.

Within the many types of plants and facilities, maintenance and contract workers can find themselves working in or around confined spaces. Entering and working within confined spaces can result in serious injury or death to the workers due to:

- Engulfment
- Lack of oxygen
- Elevated levels of fuel vapors/ explosive atmosphere.

Confined spaces also create additional concerns due to their inherent design and limited entrance and exit (confined). In the event a worker is injured and/or becomes unable to exit the space under his/her own power, rescue must take place, but only by trained and qualified rescue personnel.

Rescue procedures for confined spaces can be very tricky and dangerous, even for the trained rescuer, so these procedures must be well thought out, written, specific to known spaces (whenever possible), with rescue workers trained and routinely retrained through mock rescue drills, and appropriate and well maintained equipment purchased and immediately available during all confined space entries. Confined Space Permits and Rosters, specific to the entry location, are a standard requirement.

Fall Management

Falls remain the leading cause of fatalities in the construction industry. This is alarming considering the technology, training and equipment available.

Falls resulting in fatalities or serious injuries result in high costs. It is essential from both a moral and economic standpoint that the wrap-up project sponsor seek to eliminate and/or control the potential fall exposures that occur on construction projects.

Fall exposures can be controlled on maintenance and construction projects. It takes planning, communication, engineering, training and execution. There must be consistency in the implementation and expectations of fall management requirements governing the plant/facility. For a successful fall management program to exist, there cannot be one set of rules for one group and another set of rules for other groups.

From the outset, a maintenance wrap-up project must determine what trigger height will drive the fall management program. At a minimum, a fall exposure of six feet and greater, regardless of the trade or activity, should mandate that workers exposed at this height be protected from the potential fall exposure. Many plants/ facility maintenance operations already mandate a four-foot trigger height due to the many potential fall exposures throughout the site that occur at lower levels and so that the construction and maintenance and facility operations workers all abide by the same consistent policy. Ideally, all fall exposures should be prevented by determining if the fall exposure can be eliminated through engineering controls and/or alternative work methods.

Unfortunately, not all fall-related activities in construction are preventable and as a result, fall protection becomes the only option. If the fall hazard cannot be eliminated, the next option is to select the appropriate fall protection system.

One of the most important aspects of fall management is planning. To determine the appropriate corrective measures to be implemented, an assessment must be performed for every activity where a potential fall exposure exists.

A simple planning process should include, but not be limited to, the following:

- Evaluate the subject work area and the activity
- Identify the fall exposures associated with the activity
- Determine who will be exposed to the fall exposures
- Evaluate the process for and the needs to complete the activity
- Identify what method of fall protection will be used for each exposure identified
- Educate and train the workers involved.

Scaffolding

With the many different types of facility/ plant configurations, processes and equipment, scaffolding needed to access elevated work locations can become intricate and specialized.

In many situations, the standard configurations are not appropriate or effective. As a result, the design and installation of these scaffolds are performed by scaffolding subcontractors and by general contractors who have

created "in-house" scaffolding companies or teams of workers who are trained and specialize in these facility installations. Scaffolding may be stored on site in semi-permanent yards, especially for long-term maintenance operations where "nested" contractors have permanent work crews assigned to a location.

- Subcontracted scaffolding operations can serve the needs of all contractors and the plant/facility.
- Self-performed scaffolding operations can serve the GC's own needs as well as other individual contractors by a contract agreement.

With the potential configurations of scaffolding within the facilities, it is important that, although scaffold locations may be restricted and confined, appropriate access to the scaffold (attached ladders) is provided and maintained. In addition, end rails, swing gates and other fall protection components should always be utilized.

To prevent potential falls while accessing and exiting scaffolding, devices can be purchased and attached to either scaffolding frames or the ladders (fixed or portable) to allow the workers to tie off while ascending or descending the ladders. Another alternative to climbing devices is a ladder cage. Scaffold manufacturers sell self-closing swing gates for the scaffold end sections and access points. This allows the workers to access the platforms from the ladder and the gate will then close, creating the protected end section.

As a result of the many different configurations of scaffolding due to equipment, piping and other obstructions that must be considered when it is designed and erected, it is critical that the scaffold is erected properly and inspected routinely. The scaffold should be marked/tagged appropriately to make workers aware of the scaffold's condition and whether or not it is safe to use, with or without additional fall protection requirements. Scaffolds must be designed by a qualified person, constructed and inspected by competent persons, and loaded in accordance with that design only.

Cranes and Rigging

Virtually every construction project today relies on cranes in one form or another. They are used to hoist and place structural components and building materials, dredge rivers and lakes and build bridges and dams. It is for these reasons - together with the variations in design, capacity and capability - that cranes are to be revered, respected and fully understood.

Cranes often are the most valuable single piece of equipment on a construction project, as well as the piece of equipment that a construction project cannot operate without. It is critical that, if a crane is operating on your job site, you are aware of its fundamental operation, so that it can and will be used properly and safely. It also is critical that qualified professionals be part of the process and that proper training and certification be required. No written document is a substitute for proper training, certification and experience. Whenever cranes are used, education, training and certification are essential.

While numerous things can go wrong when cranes are used in construction, there are many practices that help to increase safety. Involving trained personnel and professional engineers and making sure that safety is part of the culture of the workplace are keys to helping minimize the risks. Some best practices include, but are not limited to:

- Crane operator licensing and certification that meet applicable federal, state and local requirements to ensure that operators are capable of running their assigned cranes and complete the associated tasks
- Procedures in place and documented to ensure rigging operations/activities are performed by qualified and trained personnel
- Logistics plans identifying type, size and location of cranes, ensuring coordination when multiple cranes are working in the same vicinity, whether by the same contractors or by others
- Crane picks, regardless of size, engineered to ensure hoisted loads are within the crane's rated capacity limits
- Pre-planning safety meetings to coordinate the responsible parties, including responsible contractor for the operation, the qualified rigger and the crane operator
- Procedures/protocols implemented for the initial and ongoing inspections of cranes
- Utilizing independent third-party crane inspection organizations to inspect and document the assembly and disassembly of the crane
- Hiring crane specialists to be on site as permanent (nested) contractors or creating an in-house crane and equipment group that is responsible to ensure all cranes are inspected and cranes and operators meet all safety requirements before they are allowed on site and erected.

Subsidence (Earth Movement)

When performing capital improvement projects and/or facility expansions that require excavations for foundation support, utility installation or relocation or other purposes, there is the potential for surrounding soils to move for a variety of reasons, including but not limited to:

- Type of soil
- Excavation of soil creating voids causing surrounding soils and/or structures to shift / move
- De-watering operations, where subsurface water is removed, creating voids that cause surrounding soils and/or structures to move
- Inadequate foundation support for the soil conditions where the structure/ equipment will stand
- Previously disturbed soil
- Construction traffic and heavy equipment movement, causing continuous vibration.

A geotechnical evaluation of the proposed construction site should be performed. This analysis will typically be completed utilizing a number of tools and resources such as, but not limited to, soil borings, local geographical maps and previous analysis, seismic reports, water table studies, the proposed design and construction of the project, and historical data for weather conditions and flooding.

The entire geotechnical evaluation and analysis should be coordinated, monitored and reviewed by a licensed geotechnical engineer. Once the analysis has been completed, the engineer provides a report that explains the process, tools and resources utilized to complete the evaluation, and should include the overall findings and any recommendations for design based on those findings.

This analysis and subsequent report must be fully understood, and any findings and recommendations are incorporated into the design and construction of the project.

Any required inspections recommended by the geotechnical engineer are completed and any changes from the original design on which the geotechnical report analysis and findings were based are then provided to the geotechnical engineer for review and approval before the changes are incorporated into the final design.

Trenching and Excavation

During maintenance operations and capital improvement projects, there may be the need for trenching and larger-scale excavations for utility (water, gas, electrical, sewer, etc.) relocations, repair or placement, and for new supporting structures (footings, foundations, support pads, etc.).

Striking a buried underground utility may result in worker injuries, plant damage or damage that results in a toxic release into the surrounding communities. State and local municipalities have their own utility mark-out (One-Call) requirements that should be followed as they apply to your work. In addition, the facility itself should also have detailed schematics identifying the known locations and contents of buried utilities in and around their facilities and property. This along with along with a plant specific utility locating and marking policy and procedure can help in preventing underground utility strikes.

Any contractor whose scope of work requires trenching or excavation work should be required to submit a Job Hazard Analysis (JHA) that is reviewed and approved by the facility safety department before authorizing the work to commence. Contractors who are authorized to perform the work should be issued a safe work permit (once the JHA is approved) that details, at a minimum, the location(s) where excavation and trenching will take place, the authorized scope of work, competent person responsible for the trenching and excavation operation and any specific safety or environmental precautions or protocols that should be followed.

One proven means to safely excavate in and around plant/facility utilities is through hydro excavation rather than conventional means that use mechanical excavation equipment, such as excavators, track hoes, etc.

Hydro excavation has become popular as a safe, non-destructive alternative to the standard means of trenching and excavating. Hydro excavation typically utilizes high-pressure water, or sometimes compressed air or both, to break up and loosen the soils, then remove the soil using onboard industrial-strength vacuums. A hydro excavator is a self-contained unit (truck) with onboard storage tank, vacuum system, water pumps and water supply. They are specially equipped with non-sparking water jet or air tubes as well as rubber tipped vacuum hoses to prevent damage to utilities.

Another benefit of hydro excavation equipment is that rubber hose extensions can be connected to the main vacuum hose, allowing the crew to extend the length and reach of the vacuum to locations where conventional excavator equipment cannot reach.

Construction Motor Vehicle Traffic

As a result of maintenance activities taking place, especially during major turnarounds where a facility may be shut down entirely, facilities can contract and bring in hundreds, if not a thousand or more, local and national workers to complete the required activities. These maintenance operations will be, as stated previously, on a set and firm schedule so it's highly likely work will take place during both day and night shifts.

Some of the biggest impacts to the surrounding areas (towns, local roadways, highways, businesses, etc.) and within the plant/facility grounds will be the additional traffic volumes, the possible construction of new and/or temporary roads, the addition and/or removal of traffic control signage, and the reconfiguration of streets/roads and traffic patterns (one-way, two-way, closed, etc.). With so many more workers entering the facility during turnaround activities, vehicle traffic can be far heavier. With workers driving in from different areas of the site's state or from other states, local roads and highways can become congested during shift changes, slowing traffic in and around local towns as well as the facility access roads themselves, potentially creating unsafe conditions if there is not adequate planning.

The increased traffic volumes will create additional hazards that should be considered and addressed before they affect worker safety and the local community. Planning for the additional traffic volume needs to occur well ahead of the turnaround activities and, if it will affect the local communities, information should be released to the public notifying them of the schedules and what to expect, so they can be prepared as well.

Work trucks and vehicles entering the facility should be restricted by need. This will help limit the number of additional vehicles. Those allowed to enter should be properly identified with the company name and issued an authorized entry permit. In addition, the drivers of these vehicles should be identified and properly trained.

Many facilities utilize the services of in-house of third-party security, police departments and traffic safety groups to patrol and monitor in-plant traffic as well as contractor parking lots. These groups commonly have the authority to issue traffic tickets for identified violations, visually inspect the contents of truck beds and items visible through vehicle windows, deny facility access to violators as needed, and request that driving privileges be taken away from repeat violators or that they be removed from the project according to the written policy.

Respirable Crystalline Silica

According to OSHA, about two million construction workers are exposed to respirable crystalline silica in over 600,000 workplaces. OSHA estimates that more than 840,000 of these workers are exposed to silica levels that exceed the new permissible exposure limit (PEL).[3]

Around 2.3 million workers are exposed to crystalline silica on the job. The hazard exists when specific activities create respirable crystalline silica dust that is released into the air.[4]

It is important that materials and tasks/activities that contain or have the potential of generating respirable crystalline silica are identified and evaluated in your efforts to protect workers from the hazards associated with respirable silica. The Chubb Silica In Construction Resource Guide is available to assist you and intended to provide insight into respirable crystalline silica, its affects as well as an overview of the new silica standard and how it applies to you.

Crystalline silica is a commonly found mineral that is used in construction materials such as sand, concrete, stone/rock and mortar. Crystalline silica is also used to make products such as glass, bricks and concrete. Crystalline silica is most commonly found in quartz and is present in many types of rock.

In the construction industry, respirable silica can be found in many common materials and generated from routine work activities such as:

- Working with brick, block, concrete and rock grinding, crushing, saw cutting, drilling, mixing mortar/grout and industrial sand
- Mechanical equipment, using sweeping machines, concrete breakers, hoe rams, shears, drilling rigs and grout machines
- Use of hand and power tools, drills, circular saws, mechanical saws, jack hammers/hell dogs, brooms and blow pipes
- Demolition activities in building structures, interior renovations, bridges and utility vaults
- Miscellaneous activities from working around other contractors creating silica dust on multi-employer worksites.

In order to fully understand the standard's requirements, the intent of each section of the standard, as well as the analytical data and research behind the rulemaking, it is recommended that you obtain a copy of the Federal Register and review it as you work through your process of determining how or if the new standard affects your company as well as during program implementation.

This standard is written as to place required responsibilities on the employer, ensuring that all aspects are completed, including but not limited to: determination of potential exposures; workplace practice controls; implementation of a written exposure control plan; medical examinations; employee notifications and training.

The language of this standard is very specific in outlining the employer's role and responsibilities and should be reviewed in depth so that you have a full understanding of what is required and your options under the standard.

Fire Protection

Among the many processes taking place at the different types of plants and facilities, there are a number of tasks that occur during maintenance and capital improvements that create the potential for fire and explosion, such as during

During any hot work operations, trained and authorized "fire watch" personnel should be in-place to monitor the surrounding areas for any signs of fire.

pre-treatment, distillation, solvent extraction and de-waxing, and cracking processes that occur during refinery operations.

It is critical that during plant operations and contractor activities are evaluated continuously, new equipment, chemicals and feedstocks are reviewed, and the facility's fire protection plan, equipment and procedures are updated accordingly.

Depending on the process being protected, any number of specialized fire protection systems can be determined necessary for that environment – for example, concrete or other insulation on columns and supports, chemical extinguishing agents, and fixed water spray or fog systems where insulation is not feasible and where fire water hose streams cannot reach.

Hot Work (welding, cutting, grinding or other ignition producing activities)
Hot work operations are typical and routinely performed during turnarounds, shutdowns and outages, regardless of the facility.

Flammable chemicals used in facility processes, storage tanks, fuel gas, residue from previous work, dusts and other materials can be ignited due to the heat, sparks and slag created during hot work. As a result, specific controls must be in place to reduce and/or prevent this from occurring:

- Welders should be trained and possess proper certifications, depending on the work to be performed, such as:
  - Pressure Piping - ASME B31 for pressure piping repairs (welding may have to be by certified welders)
  - Boilers and pressure vessels - ASME "R" stamp.
- When hot work must be completed, hot work permits should be required in addition to a completed hazard analysis and pre-planning. Some companies designate "Open Flame" hot work vs. "No Flame" hot work, and the permits are specific by each type of hot work.
- Areas to be welded, cut or otherwise heated must be cleaned of any combustible residue and any combustible and flammable materials removed from the area.
- Shut down or isolate air duct, overflow lines, vents, conveyor systems, augers or other systems that have the potential to carry heat, sparks and slag to other locations where combustible/flammable materials may be located. Also consider those same systems that have the potential to carry gases and vapors to the hot work.
- When working on piping systems, vessels or other storage tanks, special precautions must be taken to ensure flammable gases, vapors, chemicals or other materials are purged and, in some cases, inert gas is used to prevent fire or explosion. (See Fuel Gas Purging section below)
- Ensure fire extinguishing devices (extinguishers) are immediately available in the event they are needed. Ensure the type and size of the extinguisher is appropriate for the potential fire that may occur.
- Routinely inspect and verify that permanent fire extinguishing systems, such as sprinklers, standpipes, and chemical systems are tested and fully functional.
- During any hot work operations, trained and authorized "fire watch" personnel should be in-place to monitor the surrounding areas for any signs of fire; this could require fire watch personnel on multiple floors at one time. The fire watch should be designated by a colored vest other than that of the everyday workers and he/she should know exactly where the fire extinguisher is located and when it was last inspected. The fire watch should also be required to stay in position for a predetermined period of time after welding and cutting has ended (typically 30-60 minutes), to ensure no residual ignition sources remain or fires ignite. The designated fire watch can have no other duties.

Hot Work on Storage Tanks

Fires and explosions have been known to occur in/on or near storage tanks (tank farms, refineries and other locations) as a result of hot work activities on or near the tanks.

Welding, cutting, grinding, etc., takes place on the tanks themselves or to affixed catwalks, valves, vents, openings, or other piping and controls. Many times, accidents result from a flammable vapor coming in contact with an ignition source created by welding, cutting or grinding that was performed in, on, or near tanks that contained flammables.[5]

In some cases, the presence of a flammable material or atmosphere was completely unknown to the workers and many times the workers have no knowledge that an explosive amount of flammable vapor had accumulated. Welding, cutting or grinding inside of tanks may require the implementation of the Confined Space standard, according to the configuration and the conditions, existing or created. In those cases, a comprehensive Confined Space analysis/assessment must be completed.

When welding, cutting or grinding takes place, the heat, sparks or slag generated can cause the flammable/combustible material or atmosphere to ignite and explode or expand. The expansion and pressure created can cause leaks from openings, cracks or built-up pressure until there is ultimately a failure. The failure can be the tank bursting under the pressure or the escaping gases igniting.

Examples of Welding Accidents

- October 19, 2008 – Two contract workers were killed by an explosion that occurred while they were welding above a series of three interconnected crude oil storage tanks. The explosion occurred when the workers attempted to weld a bracket on top of one of the tanks, near an atmospheric vent. Because the tanks were interconnected, oil flowing into an adjacent tank likely displaced flammable vapor into the tank being welded. The vapor escaped through the vent and was ignited by welding sparks.[5]
- March 31, 2009 – Two employees were using an oxygen-acetylene torch to loosen a fitting on an old fuel tank. The workers were unaware that the tank contained residual hydrocarbon liquid and vapor from an unknown prior use. The tank was not cleaned or purged before work began. Shortly after applying heat to the tank, an explosion occurred, blowing the end of the vessel off. Both employees were airlifted to a regional burn center, where they were treated for burns covering 30% to 50% of their bodies. [5]

To avoid the potential for fire and explosion while performing hot work in, on or near storage tanks, the following are some of the safe work practices that should be considered: [5]

- Whenever possible, avoid hot work and consider alternative methods.
- Prior to the initiation of hot work, perform a hazard analysis/assessment that identifies the scope of the work, potential hazards and methods of hazard control.
- Conduct effective continuous air monitoring in the work area, using a properly calibrated combustible gas detector prior to and during hot work activities, even in areas where a flammable atmosphere is not anticipated. It is recommended that the affected personnel wear individual personal gas monitors during the hot work operations.
- In work areas where flammable liquids and gases are stored or handled, drain, clean, vent and/or purge all equipment and piping before hot work is conducted. When welding on or in the vicinity of storage tanks and other containers, test and, if necessary, continuously monitor the air in all surrounding tanks or adjacent spaces (not just the tank or container being worked on) for the presence of flammables and eliminate potential sources of flammables.
- Ensure that qualified personnel familiar with the specific site hazards review and authorize all hot work and issue permits specifically identifying the work to be conducted and the required precautions.
- Train personnel on hot work policies/ procedures, proper use and calibration of combustible gas detectors, safety equipment and job specific hazards and controls in a language understood by the workforce.
- Provide safety supervision for outside contractors conducting hot work. Inform contractors about site-specific hazards including the presence of flammable materials.

Fuel Gas Purging

During maintenance operations and/or capital improvement projects, the scope may require repair or replacement of fuel gas piping. When new fuel gas piping is put into service or when existing piping is returned to service after interruptions, it is typically necessary to purge the lines of air. Purging new or existing gas piping into buildings has proven to be very hazardous due to the possible accumulation of gas above the lower explosive limit (LEL), which has led to several injuries and fatalities due to related fires and explosions.[6]

Examples of Gas Purging Accidents[7]

- The ConAgra Slim Jim plant in Garner, North Carolina, where an explosion killed three workers and sent 71 to the hospital.
- An explosion at a fitness center in Cary, North Carolina, a short distance from the ConAgra facility, which collapsed the roof, severely burned two people, and injured four others
- An explosion that burned two plumbers at a school in Porterville, California
- An explosion at a hotel in Cheyenne, Wyoming that severely burned two plumbers
- An explosion at a 30-story hotel under construction in San Diego, California that injured 14 workers, including three who suffered severe burns

Personnel involved in gas purging operations should be fully trained and knowledgeable about safe gas venting practices, the proper use of gas detectors and the danger of relying on the sense of smell alone to detect gas releases.

U.S. fuel gas safety codes (NFPA 54, National Fuel Gas Code, 2021 edition)[8] require that new piping installations be pressure-tested with air or an inert gas prior to initial operation, and this activity requires purging during the introduction of natural gas. Purging is commonly performed in one of two methods:

- Fuel gas is used to directly displace the air, or
- Inert gas is used to displace the air and then fuel gas is used to displace the inert gas.

These operations must be pre-planned and completed only by trained and experienced personnel. Strict procedures should be implemented to control the potential for fire and explosion. Recommended safety working procedures include, but may not be limited to:

- Purging gas piping indoors should only be completed in limited circumstances where purging outdoors is not practical. If the purging must be completed indoors all nonessential personnel should be evacuated, all possible ignition sources should be controlled or eliminated before the purging begins, and ventilation should be adequate to maintain the gas concentration well below the lower explosive limit at all times.
  - If necessary, additional ventilation should be used to supplement existing systems
  - Where practical, directly vent purged gases to a safe location outdoors, away from people and ignition sources. This can be done using a temporary hose or piping or permanently installed vent pipes, depending on the facility design.
- Always use combustible gas detectors to monitor gas concentrations during all purging operations; never rely on odor alone to detect releases of fuel gases.
  - An odorant, Mercaptan (rotten egg smell), is added by the utility company to fuel gases, such as natural gas and propane, to warn workers and consumers of releases. However, the odor is highly subjective and the ability to detect the smell can vary from one person to another. In addition, some people can become desensitized to the smell as a result of long-term exposure to it and new gas pipes and containers can react with or otherwise remove the odorant, an effect known as "odor fade."
  - To ensure any gas leaks are detected, sampling should be conducted frequently or continuously at appropriate locations.
- Personnel involved in gas purging operations should be fully trained and knowledgeable about safe gas venting practices, the proper use of gas detectors and the danger of relying on the sense of smell alone to detect gas releases. Training should include the problem of odor fade in new gas piping systems.

Combustible Dust

The build-up of combustible dust is another exposure that may be encountered during maintenance operations. Many industries have the potential to create combustible dusts. This exposure must be evaluated and controls put in place along with procedures regarding dust prevention, cleanup and disposal efforts.

Operations and processes within industrial facilities can create different dusts that, if left to collect, can lead to explosions or flash fires. Dusts generated from materials, such as paper, sugar, aluminum, magnesium, wood and textiles, for example, are known to generate dangerous dusts. Fire and explosions related to these accidents can result in serious injuries or death, can cause major damage to the facility's structure and equipment and result in related loss of production. Many times, plant operations and management are unaware of the dust hazards and potential dangers they pose.

Facilities must comply with the National Fire Protection Association Standard 484, which details requirements for dust collection systems, dust cleaning frequency and building construction and egress provisions.

Process Piping and Vessels

Line Breaking/Equipment Opening

Within the plant/facility there are many process taking place, and related piping systems and equipment that may contain a number of different materials that can be harmful to health as well as have the potential for fire and explosion, such as fuel gases, hot dusts, toxic/caustic/corrosive chemicals, steam, extreme temperatures and other flammable or combustible materials.

Line breaking and opening of equipment is necessary to perform routine maintenance, cleaning and repairs of equipment and piping systems. If not performed in a well thought out and controlled environment, serious injuries, death and/or major damage to facility process equipment can occur.

There should be a written Line Breaking and Equipment Opening policy in place that establishes processes and procedures necessary to safely work on lines and equipment at the facility.

Depending on the contents contained within the lines and/or equipment to be worked on, these procedures can vary. The procedures should address items such as, but not limited to:

- Job Safety Task Analysis
- Line breaking/equipment opening permits
- PPE – clothing, respirators, eye and face protection, etc.
- Potential hazards as a result of breaking the line
- Air monitoring before, during and after work
- Contents and Safety Data Sheet (SDS) reviews
- Safety equipment and procedures for items such as:
  - Clearing the area
  - Warning signs, barricades
  - Monitoring and other equipment needed to perform the operation
- Confined Space entry
- Lockout/tagout
- Fire protection
- Breaking/opening, closing and quality check (testing) of the completed work
- Blanking, flushing and draining, purging, using inert gases
- Emergency response procedures.

The information contained in the line breaking/equipment opening permit should be reviewed and approved prior to allowing any work to take place. All affected workers should be trained using the facility's written policy as well as the information required in the permit, and the training should be documented with signatures of those in attendance.

Hydrostatic Testing

Hydrostatic testing is a very common method employed for testing pipes, vessels or other hollow equipment to ensure they meet applicable safety and durability standards. Testing is originally performed when the pipe, vessel or other equipment is manufactured and must be retested at regularly scheduled intervals to maintain the pipe, vessel or equipment's integrity and safety.

Hydrostatic testing is performed to test strength and leak resistance, using a testing fluid to apply internal pressurization. The testing fluid is "over-pressurized" according to industry, manufacturer or customer specifications and is usually dyed so any leakage can be easily seen. In addition to the pressure of the testing fluid, the test is also carried out over a predetermined period of time to ensure the pipe, vessel or other equipment can maintain the internal pressure (over-pressurized for a safety factor) and maintain that pressure for an extended period of time. This ensures that the pipe, vessel or other equipment will be able to maintain its typical working internal pressure when operating under expected conditions.

During maintenance and turnaround activities, hydrostatic testing is performed more often due to the need for vessels, pipe or other equipment to be opened for inspection, cleaning, repair or replacement of individual components.

Due to high pressures applied to the internal components of the pipe systems, vessels and equipment during testing, there is the potential for serious worker injuries if the process is not performed with proper care. Appropriate steps must be taken when preparing the test, during the pressurization period and when the test is completed, and the testing fluid is de-pressurized.

Pressure Vessels (boilers, water heaters, compressed fuel storage tanks)

Pressure vessels are very common in process facilities, whether it is a storage tank, a boiler or other pressurized vessel designed to operate at pressures above 15 pounds per square inch gauge (p.s.i.g.). Pressure vessels can store enormous amounts of energy, and if cracked, corroded and/or damaged, pressure vessels can result in leakage or rupture failures.

Potential health and safety hazards from leaking vessels include poisonings, suffocations, fires and explosion hazards. Rupture failures can be much more catastrophic and can cause considerable damage to life and facility equipment or other property. The safe maintenance of pressure vessels, in accordance with appropriate codes and standards, is essential to worker safety and health.

The ASME - American Society of Mechanical Engineers - International Boiler and Pressure Vessel Code, 2019 Edition establishes the rules of safety governing the design, fabrication, and inspection of boilers and pressure vessels and nuclear power plant components during construction.

Chemicals and Gases

In many industries, such as refineries and pulp and paper, it is common for toxic and hazardous chemicals to be utilized in the different processes. It is also common for processes to use or create toxic and hazardous gases as a byproduct. In either case, it is important that all available information related to these chemicals and gasses be obtained and fully understood before they are incorporated into system processes, and before the system is operational, which may result in the creation of gasses or otherwise used within the facilities' appropriate processes.

Hydrofluoric Acid (HF)

Hydrofluoric acid is highly corrosive. It is known to be able to dissolve many different materials, including glass and metals. It is used in the oil refinery process known as alkylation. Due to the reactivity of hydrofluoric acid on glass and metal, the acid must be stored in a proper form of container.

In gas form, such as hydrogen fluoride gas, it is an extremely toxic poison that can cause immediate and permanent lung damage and other bodily damage, such as with the eyes. Hydrofluoric acid is also known as a contact poison, which means that if it contacts the skin, it has the potential to cause deep burns followed by tissue death.

Because HF interferes with the body's nerve functions, symptoms of exposure to HF may occur but not become noticeable until later. Pain related to burns by HF can go unnoticed as they are not painful at the outset. This lack of noticeable symptoms can lead to a delay in medical care, increasing the extent and seriousness of injuries.

Due to the extreme dangers of HF, only trained and qualified personnel should be authorized to handle or work on systems containing it. Other precautions include, but may not be limited to:

- Always review the SDS before handling
- Handle HF under a fume hood
- A fully equipped eye wash and safety shower must be located within the immediate work area
- Use chemical splash goggles
- Utilize appropriate chemical hood, face shield and goggles, over garments
- Use appropriate neoprene gloves (acid resistant).
- Make sure an HF antidote gel is in the immediate work area and within easy reach in the event of contact. Calcium gluconate is a readily available gel.

Caustic Soda/Lye (Sodium Hydroxide - NaOH)

Sodium hydroxide is a metallic base material used in many industries, such as chemical, pulp and paper, and food processing, and it also serves as a cleaning agent. From a hazard standpoint, it does not burn or explode – however, if it comes into contact with the skin, it can cause severe burns as well as blindness if it contacts the eyes.

Other concerns are:

- The contact of sodium hydroxide with certain other acids will create a highly exothermic reaction, resulting in extreme heat that can cause heat burns or an ignition source.
- Sodium hydroxide is also corrosive to some metals, such as aluminum, which produces flammable hydrogen gas on contact. Hydrogen gas is highly flammable and can ignite and burn in many air concentrations. If in contact with chlorine as well, the mixture can auto-ignite and explode by sparks, heat or simply sunlight.

Although sodium hydroxide is somewhat common in both industrial and commercial use, it can cause injury, fire and explosion, depending on contact with skin or other materials such as aluminum. As with any other chemical, only trained and qualified personnel should be authorized to handle or work on systems that contain Sodium Hydroxide. Always review the SDS before handling. Other precautions include PPE such as, but not limited to:

- Appropriate rubber gloves, aprons or other outer garments
- Splash-proof eye and face protection
- Available eye wash and shower facility nearby
- Respiratory protection.

Sulfuric Acid (H_2SO_4)

Sulfuric acid is a strong mineral acid that is used in many applications. It is a primary substance utilized in the chemical industry, oil refining, iron and steel manufacturing. As with sodium hydroxide above, when mixed with water, sulfuric acid becomes highly exothermic, resulting in heat.

Only trained and qualified personnel should be authorized to handle or work with sulfuric acid. Always review the SDS before handling. Other precautions include PPE, such as, but not limited to:

- Appropriate protective eyeglasses or chemical safety goggles
- Appropriate protective gloves to prevent skin exposure, such as neoprene, butyl rubber, natural rubber or polyethylene
- Appropriate protective clothing to prevent skin exposure
- Available eye wash and shower facilities nearby
- Used under a chemical fume hood

Hydrogen Sulfide (H_2S)

Hydrogen sulfide is a colorless, flammable gas produced in large quantities by the petroleum industry. Most people recognize the H_2S by its smell, which is much like rotten eggs. In the petroleum industry, H_2S is created during the hydrodesulphurization process which, as a result of hydrogen, causes the sulfur to separate from the petroleum. Other industries produce H_2S as well, such as those utilizing coke ovens and in paper mills that use a method known as "sulfate method."

H_2S is very dangerous in facility maintenance and in new construction

In a high-enough concentration, a worker can be put into a coma with just one breath.

operations where there is the potential for H_2S to enter into excavations or confined spaces. This is due to H_2S being heavier than air, so when it enters into an excavation or confined space, it will settle at the bottom, creating a highly toxic and flammable atmosphere. If the workspace is not well ventilated and not properly tested and monitored, workers can be overcome and asphyxiated very quickly.

If exposed to low concentrations of H_2S, workers can experience symptoms such as:

- Eye irritation
- Sore throat and cough
- Nausea
- Shortness of breath and fluid in the lungs
- Loss of appetite
- Headaches and dizziness
- Irritability
- Memory loss and dizziness.

In a high-enough concentration, a worker can be put into a coma with just one breath. H_2S is also very dangerous because workers with H_2S within their work areas will smell the gas at first, but the gas will then deaden the sense of smell, giving the workers the false impression that the gas has gone, but in reality it has not and could be building up to deadly concentrations.

Personal protection for workers in H_2S environments may include:

- Always review the SDS before handling
- Training specific to the hazards of H_2S and the symptoms of exposure
- Appropriate protective eyeglasses or chemical safety goggles
- Appropriate protective gloves to prevent skin exposure such as neoprene, butyl rubber, natural rubber or polyethylene
- Appropriate protective clothing to prevent skin exposure
- Good ventilation
- Personal H_2S gas detector
- Multi-gas detector that includes H_2S monitoring
- Remove all sources of ignition from the working area
- Respiratory protection

Recognized Practices for Controlling Loss

Pre-planning
Pre-job planning may be the most important tool of any safety program. This allows for a proactive, rather than a reactive, approach towards safety. It requires the contractor to demonstrate they have planned their work in advance, identified the exposures and given sufficient consideration as to how to control the exposures.

Subcontractors should be required to submit a Job Safety Task Analysis (JSTA), or like document, to the General Contractor (GC) or Construction Manager (CM) prior to the start of their work. Once the subcontractor submits the JSTA, a meeting should be held between the GC and the subcontractor, during which, the subcontractor reviews the plan and is provided with feedback.

The JSTA should outline:

- The scope of work involved for the subcontractor's activities
- The equipment to be used to facilitate the work (e.g., scaffolding, cranes)
- The potential exposures associated with the work to both workers and the general public (non-construction plant personnel or visitors)
- The controls that will be implemented and enforced to eliminate and/or control these exposures and the necessary safety equipment required to perform work.

Once the JSTA has been reviewed and approved, the subcontractor should be required to review the JSTA with each member of their crew prior to the start of work. The subcontractor should be required to submit the signature of each employee that attended the JSTA review to document that workers received pre-planning instructions.

Quality Assurance, Quality Control and Planning
Quality control and safety represent important concerns for project managers. A construction defect is a flaw or design mistake that reduces the value of a structure and/or may cause a dangerous condition. Most wrap-up insurance programs provide completed operations coverage, which may cover up to 10 years from the time the project is completed.

Defects or failures as a result of maintenance activities can result in high costs. Even with minor defects, reconstruction may be required and facility operations impaired. Increased costs and delays are the result. In the worst case, failures may cause personal injuries or fatalities. Good project managers try to ensure that the job is done right the first time and that no major accidents occur on the project.

There are many factors that can lead to construction defects, such as:

- Improper use of or inferior materials
- Poor workmanship/construction techniques (welds, fittings or other connections)
- Improper design of mechanical, process piping, equipment control, electrical and heating ventilation and air conditioning (HVAC) systems
- Improper design and engineering analysis of site locations, soil conditions, support structures, landscaping and drainage
- Improper design or installation of building envelope systems, including curtain walls, windows, roofing, weatherproofing and flashing.

The sponsor of a maintenance wrap-up program must ensure that appropriate procedures are in place, verifying that the project(s) being constructed is per plans, specifications, regulatory requirements and building codes and maintenance activities are completed only on those identified. To accommodate this, the sponsor should require that a detailed Quality Assurance/Quality Control (QA/QC) program be developed and implemented, including controlled inspections performed throughout each phase of maintenance and construction, such as pile driving; soil compaction; concrete; reinforced steel; welding; mechanical, electrical and plumbing (MEP), control systems and piping.

Consideration should be given to requiring independent third-party engineering/inspection firms be employed to perform inspections, in addition to the requirement of the construction manager and respective contractors performing the work.

Quality planning is an issue that may be poorly addressed by maintenance organizations. It is recommended that organizations employ a system for capturing and improving plans and estimates for recurring jobs from one turnaround, shutdown or outage to another. This may entail benchmarking during execution and follow-up reviews once completed to ensure the system utilized is current. Many times, follow-up reviews do not occur, and it is left to chance that the planner will remember necessary details the next time a turnaround involving the same unit is planned.

In many cases where the preparation time for planning a maintenance activity is compressed or inadequate, there is a better than average chance that plans based upon templates (or historical plans) will suffer from "cut-and-paste syndrome" and not be updated or customized specific to that situation. To assist project management, there are planning systems available that can be utilized.

Substance Abuse
A recent federal government survey revealed that the construction industry has some of the highest rates of alcohol and drug abuse. [9]

Among full-time construction workers between the ages of 18 - 49:

- More than 12% report illicit drug use during the past 30 days
- Almost 21% report illicit drug use during the past year
- Approximately 13% admit to heavy alcohol use.

According to the study, "Evaluation of drug testing in the workplace: Study of the Construction Industry," published in the Journal of Construction Engineering and Management, construction companies that test for drugs appear to have a reduction of workplace injuries.[9]

The use of alcohol and other substances while on a work site greatly influences a person's ability to perform job functions safely. With many high-risk and safety-sensitive positions within the construction industry, there is an increased likelihood for worksite accidents and injuries when a worker is under the influence of drugs, alcohol or other substances.

A wrap-up sponsor should require, as part of its Drug Free Workplace Policy, the implementation of a substance abuse testing program on the project, including at a minimum, pre-employment, random and post-accident testing.

The inclusion of a substance abuse testing program should be established at the initial stage of the wrap-up program and include review from legal counsel. In addition, in certain union environments, obstacles may be encountered because of collective bargaining agreements. In union environments, the wrap-up sponsor should engage in discussions early on with union officials in a collaborative effort to address incorporating this procedure into the project labor agreement.

Pre-qualification

Successful projects are ones in which contractors/subcontractors selected to perform their respected work are qualified and responsible. Selecting contractors solely based on the lowest bid does not always produce the desired results.

On maintenance wrap-up projects, since the sponsor is assuming the cost associated with insurance for accidents emanating from its projects, it is in the best interest of the sponsor to select contractors that have strong safety cultures and safety performance records. In many cases, there are nested long-term contractors/subcontractors already performing work within the plants/facilities that are considered for the work.

Often contractors/subcontractors are pre-qualified to determine their experience and financial background. This could include a background check to ensure they are in good standing with federal, state and/or local agencies.

A wrap-up sponsor should also pre-qualify potential contractors to determine their safety performance. Pre-qualification should include, but not be limited to:

- The company's experience modification rate over the past few years
- The company's Bureau of Labor Statistics (BLS) recordable and lost-time incident rates
- Their OSHA violation and citation history
- Their overall company safety culture and procedures
- Work experience as well as a trained and qualified workforce
- Any contractor with high incident rates must go through additional qualifications and receive plant manager approval.

It could turn out that the lowest bidder may not be the cheapest bidder if, in fact, they have a poor safety history.

Contractors/subcontractors are responsible for the safety and health of their workers and also need to ensure that they perform their work in a manner that safeguards other project workers and/or the general public that may come into contact with their operations.

Consider requiring contractors to staff their operations with full-time, dedicated safety representatives. In situations where a subcontractor is employing 25 or more workers, a full-time, dedicated safety representative should be required.

The cost for each subcontractor to provide a dedicated, full-time safety representative may be prohibitive or unwarranted. At a minimum, every subcontractor must provide a qualified and or competent person to implement and ensure compliance with safety requirements. The name and qualifications of that individual, as well as that person's responsibilities, should be provided to the CM/GC prior to the start of work.

Bid & Evaluation Process – Mandatory pre-bid meetings should be conducted to address major exposures concerns such as PPE, Fall Protection, Confined Space, Scaffolding and Lift Plans and review and discuss required Job Safety Analysis, Incident Reporting and any other site and/or task-specific requirements.

Site-Specific Safety Orientation and Training

All contractor employees should be required to attend and pass the basic and site-specific facility/plant safety training. Retraining should be required on an annual basis with training-specific badges issued that identify workers who can work within or on certain processes and/or equipment.

An employee orientation program should be developed specific to the plant or facility. This should provide but not be limited to:

- An overview of the project being constructed
- An in-depth review outlining the safety requirements and expectations set forth
- The emergency evacuation plan and procedures
- Disciplinary policy and procedures
- Substance abuse testing policy and
- Fall management procedures and requirements.

Consideration of a bilingual project workforce must also be addressed, and it may be necessary that the employee orientation be provided in more than one language.

Each person involved with the construction of the project and having access to the project site must go through the project-specific employee orientation program.

Ideally, to ensure a consistent orientation is being provided, the delivery of the orientation should be presented by the project entity responsible for coordination and oversight of the project safety function, usually the CM or wrap-up sponsor or their designated third-party training provider. Area Safety Councils are common to this task.

Return to Work (RTW) Program
A return-to-work program is a proactive way for employers to help injured workers return to productive and safe employment as soon as physically possible. Its goal is to help employees return to work more quickly and under safe conditions during the healing process after an on-the-job injury or illness. RTW options can involve transitional duties – temporary work tasks that are meaningful and productive and/or a gradual return to work.

Advantages of an RTW program for the company include:

- Reduced staff turnover and training costs by retaining experienced and knowledgeable workers
- Reduced Workers' Compensation costs because workers are able to return to employment sooner
- Reduced time lost because workers know that their employer will make whatever reasonable accommodations may be required to facilitate their return to work
- Minimized accident costs, such as worker benefits, hiring and training replacement workers and the cost of inexperienced workers
- Decreased long-term Workers' Compensation experience rating costs
- Demonstration of concern for the best interests of workers and indication that workers are viewed as valuable members of the organization.

Advantages of an RTW program for the workers include:

- Continued employment, providing job security, self-worth and financial independence
- Maintained financial benefits, including pension, medical and dental plans, insurance coverage and vacation credits
- Sustained contact with co-workers and friends
- Focused interest on the workplace and not the disability
- Reassurance that they are valuable workers
- Maintained dignity and self-worth by remaining productive
- Maintained job skills
- Minimized loss of physical fitness and muscle tone due to inactivity
- Earlier resumption of "normal" life, supporting family members, financially and emotionally, and participating in leisure and social activities.

Optimally, the RTW program will include:

- An injury case management plan/process requirement for all contractor claims
- A dedicated individual assigned responsibility to manage RTW (works closely with case manager, physician, safety director and project managers to determine limitations and approved assignments)
- Identified temporary light-duty positions/assignments
- Medical facility provided on site, staffed with either an RN, EMT or Physician
- Should a worker choose to refuse initial medical treatment for a reported accident, they should be required to sign a written statement stating such.

Security and Emergency Action Plans
With the potential for catastrophic damage and loss of life if a petrochemical, petroleum refinery, and/or power generation facility were to become the subject of domestic or international terrorism, it is commonplace that all workers are pre-screened via background investigations/check prior to being authorized entry into the facility.

A common method for tracking and identification is with the issue of electronic badges to those workers who have successful completed any required training, orientations, substance abuse testing or other required items and documentation. These badges are electronic and can be monitored and controlled by the security departments. Should a worker be considered a threat or fail to comply with or maintain facility training requirements, the site security teams can control access by computer, not allowing the card holder access to the site.

In addition, in the event of an emergency, electronic access passes can give a real-time record of where workers are and can be extremely useful in accounting for them in the event of a safety or environmental incident. A check-in station might be reserved at a safe "all clear" site.

Facilities and plants should have in-plant emergency response teams trained and at the ready in the event of fire, hazardous materials exposures, medical, high-angle/structural and confined space rescue and oil spill containment and cleanup.

Communications plans should be written, implemented and fully communicated to all operations and contract workers. These plans outline locations of communications devices, whom to notify in the event of emergencies and how to use the devices so work and emergency response teams can respond to address the issue and workers can evacuate quickly and safely. Specific communications devices, such as telephones or radios, should be available in designated locations throughout the facilities.

Additional Practices for Controlling Loss
- Site and task-specific safety plan requirements. Contractors have an approved safety program that should be approved before the work begins.
- Contract safety personnel work closely with and monitor the contractors' safety culture and activities. Contract safety personnel meet with the contractors regularly.
- Investigation of all accidents including near misses. Accident investigation results are turned into lessons learned and distributed for education purposes.
- Accidents are reported within 24 hours of incident.
- Safety training specific to each individual process and their specific hazards. Training should be task specific and a method to ensure that workers understood the information they were provided is established.
- Any construction or other outbuildings (offices and trailers) are located as remotely as practical from any production or other activities, processes and operations.
- Emergency showers and eye wash stations are in place, inspected, clean and functioning appropriately. The number of stations active in the facility should be based on the number of workers in addition to the potential for exposure.
- Whenever possible, emergency medical stations and medical personnel, such as nurses and/or EMTs as well as strategically placed first aid stations, should be in place to assist in potential injuries. Staffing of medical personnel and treatment facilities within the facility can be an effective means to limit the effects of the injuries and save on treatment costs.
- Even though on-site medical facilities and staff may be provided, the location of approved off-site facilities must still be planned for and outlined in the emergency response plans and medical procedures.
- Many facilities, such as pulp/paper and petroleum, are located in southern areas of the country where heat and humidity can become very dangerous and, in some locations, record temperatures and humidity can last record-setting consecutive days. It is important that workers are provided with facilities to assist them in controlling hydration and body temperatures to avoid heat stress, exhaustion and stroke.
  - Hydration stations should be provided throughout the maintenance and construction areas of the facilities
  - Where possible, shade should be provided in addition to any hydration.
  - Individual contractors should be required to provide appropriate amounts of cool, potable water for their crews to drink throughout the day
  - Contractors are required to submit a heat-related stress plan to the facility safety team in preparation for increasing temperatures
- Liquid waste from cleaning operations can be generated that may not be allowed to enter any in-plant industrial sewer. Identify these potential materials so the appropriate handling and disposal can take place.

Safety, Health and Environmental programs are an evolution - adjusting and changing based on risk and exposures and incorporating new or enhancing existing safety practices, equipment and procedures.

Conclusion

Although these related industries and their maintenance operations are known to have established policies and procedures, a longstanding and experienced contractor base and successful risk management and safety, health and environmental programs, there is always the potential for serious injuries or death to workers as well as the general public who live near these facilities.

Safety, Health and Environmental programs are an evolution – adjusting and changing based on risk and exposures and incorporating new or enhancing existing safety practices, equipment and procedures. No program is perfect; therefore, it is important to stay diligent, pro-active and innovative in your efforts to continuously improve. As history has shown time and again, even facilities considered to have the best safety, health, environmental and quality programs in place can have catastrophic accidents resulting in death, serious injuries and costly property damage. Complacency is not an option.

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3. **Frequently Asked Questions**: *Respirable Crystalline Silica Rule*
4. **U.S. Chemical Safety and Hazard Investigation Board**, *February 2010, Seven Key Lessons to Prevent Worker Deaths During Hot Work In and Around Tanks - No. 2009-01-SB*
5. **U.S. Chemical Safety and Hazard Investigation Board**, *September 2009, Dangers of Purging Gas Piping into Buildings, No. 2009-12-I-NC*
6. **National Fuel Gas Code, NFPA® 54, ANSI Z223.1** *defines a piping purge as "to free a gas conduit of air or gas, or a mixture of gas and air." The National Fire Protection Association (NFPA) develops widely recognized consensus fire protection codes and standards. Another widely recognized family of fire protection codes is published by the International Code Council which includes the International Fuel Gas Code. Both codes address safety guidance and requirements for the installation and operation of fuel gas piping and equipment.*
7. **National Fuel Gas Code, NFPA® 54, ANSI Z223.1**; *the International Fuel Gas Code; IFCG. The fuel gas codes require that piping beyond specified lengths be purged with an inert gas based upon the nominal pipe size.*

- **Department of Health & Human Services Substance Abuse and Mental Health Services Administration**

OSHA Technical Manual (OTM), TED 01-00-015 [TED 1-0.15A], **SECTION IV: Safety Hazards**,

- CHAPTER 2. Petroleum Refining Processes.
- CHAPTER 3. Pressure Vessel Guidelines

Chubb Silica In Construction Resource Guide

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For additional information regarding these and other exposures, please contact your CHUBB Global Risk Advisor's Risk Engineer.

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