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INLAND RIVER SHIPYARD SAFETY

By

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requirements for the

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Abstract

Shipyard work is a hazardous occupation with an injury rate that doubles construction or general industry. Workers are exposed to constant danger due to the extreme working conditions, confined spaces, considerable heights, and surroundings. On a daily basis, shipyard workers are faced with a multiplicity of hazards that can be a great potential for many injuries due to the environments they are confronted with. Workers are consistently exposed to extreme processes such as welding, painting, and sandblasting that have a direct effect on worker's health. Though better equipment and special tools have surfaced, many workers are still being injured while employed in the maritime industry. A good way to discover means of reducing injuries is to study incidental cases from the past and learn from previous mistakes. Identifying these key breakdowns in safety that led to major incidents and analyzing corrective measure that are readily implementable can create a safer and more efficient workplace. Learning from past mistakes in shipyards is vital if we are to keep from repeating them.

Safety in inland river shipyards has increased over the years due to many new regulations set by OSHA and from employers setting clear goals to reduce incidents by implementing a comprehensive safety program. With a team effort through awareness and proper communication, employers have surrounded themselves with specialized personnel to adequately train their employees and reduce incidents.

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Importance of Shipyards and the Inland River Industry

Shipyards, which are also known as boatyards, are very important in today's economy and maritime industry. Shipyards consist of a dock string along with dry docks that accompany customers with new construction, maintenance, and the repair of towboats and barges. Dry docks are all fabricated of steel that simply use compressed air to open actuators on valves that flood their inner bottoms with water. As this occurs, dry docks are able to sink to proper levels in order to rest a barge or towboat on a dry platform. Dry docks range from different sizes with the ability to dock inland towboats up to a width of fifty-four feet by two hundred feet long. They also have the capability of docking barges up to three hundred feet long. Bigger dry docks have a capacity of three thousand tons while smaller docks are used for standard barges and smaller tugs. Some shipyards also have syncrolifts that can assist in launching new construction of barges and also for the benefit of transporting barges to land by rail system for repairs, sandblasting, and painting. All shipyards provide many different services for the river industry and employ numerous trades.

Shipyards are still being constructed and strategically located along the inland waterways systems and coasts. Our inland waterways system spans twenty five thousand miles throughout the Central United States and accounts for twelve-thousand miles of navigable waterways. The largest part is the Mississippi river system, which includes the Ohio, Tennessee, and Cumberland rivers. The Mississippi river curves through ten states in the heart of our country all the way from Northern Minnesota to the Gulf of Mexico. Along these rivers, towboats are able to transport barges that are loaded with heavy products such as petroleum, coal, grains, and other agricultural products in a safe and reliable way. These rivers play a critical role in facilitating the nation's trade by moving sixty percent of U.S. grain for export. The largest commodity moved

on our waterways is two hundred forty-four million tons of fuel a year. Coal has also been a key in the barge industry by transporting twenty percent of the nation's coal to power plants. On average, over 600 million tons of freight is shipped over the inland waterways per year. This consists of fourteen percent of domestic freight (Campanelli, 2017).

Our inland waterways infrastructure supports billions of dollars of revenue each year boosting our economy. The waterways assist many industries in the United States with reaching global markets that would otherwise have great barriers of entry. Agriculture is one of the key industries to benefit. Most agriculture is rural and quite a distance from large city centers. The proximity of the inland waterways to American farmers provides a low cost way to export American agriculture products to many different world markets. In fact, 20% of total farm income comes from these exports adds \$21.5 billion in the United States' favor towards the trade balance (Campanelli, 2017).

The inland waterways directly and indirectly are one the largest generators of employment in the United States. There are over 650,000 jobs and over \$154 billion in income directly coming from the inland waterways (Hocke, 2019). With that being said, the industries that the inland waterways support employs millions of Americans. Many of these jobs provide above average wages and fuel the American middle class.

The inland waterways assist other industries in our country as well. Oil refineries, rock quarries, and coal terminals all utilize the river industry with locations on each adjoining river. With the rise of oil exploration and production in the United States, the inland waterways provide a vital link to world markets. Other commodities such as metal ores, aggregates, heavy machinery, and other minerals rely extensively on the inland waterways.

The waterways are able to transport goods safer at a lower cost with better fuel efficiency and less emissions of hydrocarbons in the environment. The following illustration shows how dry cargo barges are more effective in transport than semi-trucks and the rail system. One standard 35' x 195' dry cargo barge is the equivalent of sixteen rail cars and seventy large semi tractor trailers.

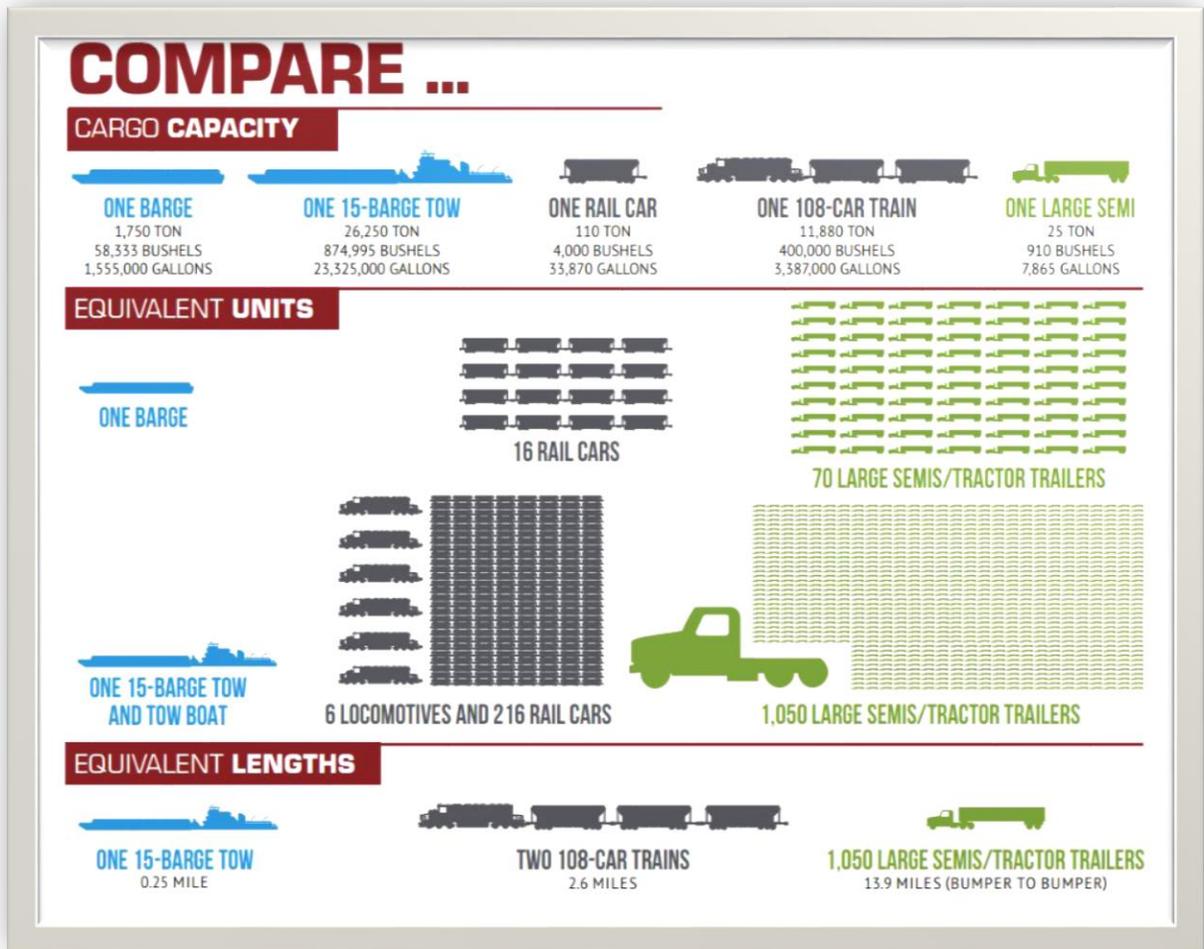


Figure 1, Barge to truck and rail car comparison.

<https://centralohioriverbusinessassociation.com/cargo-capacity-different-transportation-modes>.

Barges are the second most energy efficient form of transport, only behind large container and bulk ships. Liquid cargo barges play an important role in the towing industry as certain companies only transport petro-chemical products. Other products that are utilized in liquid cargo barges include fuel, diesel, fertilizers, and asphalt. Many of America's largest companies rely on the inland waterways for supply chain management. The following illustration shows how one standard liquid cargo barge is equivalent to forty six rail cars and one-hundred and forty four semi tractor trailers. With the rising concerns about climate change and lower emissions, the inland waterways will continue to be a vital part of transportation in the United States.



Figure 2, Barge to truck and rail car liquid comparison.

<http://www.professionalmariner.com/Web-Bulletin-2017/Study-cites-continued-benefits-of-moving-cargo-by-barge/>.

Subchapter M

In July 2018, the United States Coast Guard's Subchapter M set new safety and environmental standards for towing vessels. This was an important date for tug and towboat operations in the U.S. along with repair shipyards as the U.S Coast Guard's CFR46 regulations would affect about six thousand previously uninspected vessels on the nation's inland waterways and harbors. Each vessel will be required to carry a Coast Guard Certificate of Inspection (COI) in order to continue fleet operations. COI's are documents that describe the vessel and its owner and operators. The certificate also includes the vessel's routes, safety requirements, and number of workers who may be onboard. Towboat companies will be required to comply by annual United States Coast Guard inspections or implementing a USCG accepted Towing Safety Management System (TSMS). This will make sure that all towing vessel operators are in compliance with better bookkeeping, inspections, and correct repair of their vessels by professional shipyards. They also have the option to use an external auditor or Third Party Organization (TPO) to conduct their inspections, audits, and surveys prior to the issuance of a COI.

Companies are required to have twenty five percent of its fleet inspected each year and issued COI's so that by July 2022, one hundred percent of their fleets are inspected. If the Coast Guard boards a vessel and identifies a Subchapter M violation, the company can still be cited even though the vessel may not need a COI for a few more years. The Coast Guard will take the immediate steps to ensure the safety and health of all individuals on board and has the right to have the vessel moored or even taken to the nearest facility for repairs if any deficiencies are

found. COI's are good for five years and include many factors determined by the USCG for inspection. The Coast Guard must conclude that each vessel is in safe condition with regard to both life and property, suitable for service, and complies with all laws and regulations. The vessel must also have the proper life saving, fire prevention, and firefighting equipment that is marked and routinely inspected. Fire extinguishers are to be tagged and periodically inspected by an outside contractor and replaced once used.

Subchapter M is taking safety to new heights and making sure that the whole industry achieves to protect lives, their property, and the environment. Subchapter M is a great new compliance that will benefit more work for shipyards for years to come. Shipyards are the only facilities available to conduct ultrasonic gauging for towboats and tugs which must be done every five years. Ultrasonic gauging consists of grinding and gauging the thickness of a vessel's hull while on dry dock. Bands are to be gauged every ten feet on the sides and bottoms of hulls and any wastage of over 30% must be cut out including fuel, oil, and water tanks. As some towboats and tugs are up to fifty years old, hulls become deteriorated and repairs can be costly to vessel owners. Lap patches or doubler plates that are on the vessel must also be removed and steel must be inserted to its original specs by a shipyard supplied Coast Guard certified welder and fitter. Internal framing is inspected for wear and replaced as needed, water tight doors in shaft alleys on vessels are also checked for proper sealing. While a boat is on dry dock, a visual inspection of all underwater gear will be conducted, and a checklist will be kept on file for all repairs and findings. Set-ins and indented hull plating are typical on all parts of a vessel from bow to stern and will also be repaired along with the proper framing and bulkheads or documented for future dockings. Towing Companies that operate inland tank barges will keep the same or similar practices for repairing their barges as they do towboats rather than

maintaining two sets of standards or maintenance programs. All of these new regulations will lead to more expansion and skilled employment in the shipyard industry.

Inclement Weather

Shipyards are faced with difficult weather and surroundings on a daily basis. Shipyards are widely known for having less than favorable working conditions. Mother Nature takes a toll on the whole marine industry with record setting winds and temperatures. Shipyard employees work twelve hours a day in outdoor environments and never shutdown due to the rain, snow, or even ice.

Flooding occurs on a regular basis throughout the year due to the heavy rains along the river valleys. A few inches of heavy rain from hills and creeks that tie into our river beds can cause rapid increases in river levels in a short amount of time. Heavy Spring rains and snowmelt from northern states also assists in flooding with ice flowing down our rivers. Historic river levels have been reached in recent years and have shutdown locks and barge traffic for many miles. Shipyards are responsible for keeping track of incoming weather to protect the health and well being of their employees. River stages fluctuate causing swift currents and treacherous working conditions that in turn cause damage to towboats that benefit the economic side for shipyard repair. These high waters cause for drift and even navigational buoys to float down our waterways damaging barges, fleets, and towboats. Barge fleets have broken loose sending barges drifting downriver damaging anything in its path. Towboats have their propellers and rudders that they steer with damaged and even tore off. Drift, which can consist of whole trees

floating down our waterways, has done extreme damage to the whole maritime industry over the years. Many incidents have occurred from drift even affecting fisherman and pleasure crafts.

As river stages fall during the dry summer months, these conditions also account for dangerous environments. The extreme heat takes a toll on shipyard workers and everyone in the maritime industry. In the summer months heat index's can soar well above 110 degrees which can cause serious health issues for workers in direct sunlight. These heat related illnesses can progress rapidly if not addressed right away. This becomes a very serious problem when these tug boats are six to eight hours away from the nearest medical center. Heat exhaustion and heat strokes are two serious hazards that can occur in shipyards.

Shallow rivers also cost towboat companies in many different ways. Rivers narrow due to droughts. This causes river traffic to become restricted with long delays due to the width of the channel. As towboats idle waiting on lock passage, they average a \$10,000.00 per day loss. The standby time, fuel, groceries, salaries, and customer's goods all account for this number. The shallow channels call for lighter loads, lower speeds, and fewer barges for transport that all runs up costs.

Our aging locks also play a factor as barges can be backed up for days awaiting passage. Over the past few years, emergency closures and delays at many locks and dams throughout the system have caused operational headaches for boat companies (Glass, 2018.) The majority of our locks have exceeded their expected life and are all due for new infrastructure.

These river stages also benefit the economic side for shipyards. Towboats are more likely to ground barges and their vessels resulting in major damages and emergency dredging. They have also been known to collide with other towing vessels which immediately could impact

harm for their deck crews. Dikes also cause major damage to towboats and barges along the rivers. Dikes, also known as wing dams, are usually made of rock and run parallel to the river flow. These dikes run all along the rivers and are built to protect lands from flooding and maintain river flow. As water levels are down through certain times of the year, dikes have become a pilot's nightmare. Towboats and barges have sunk resulting in fuel and oil spills that endanger the environment resulting in emergency salvage operations that involve the United States Coast Guard. Upon completion of these salvages, the damaged equipment is initially taken to the nearest shipyard for repairs.

Extreme cold conditions during the winter months also cause severe problems in shipyard environments. Dry Docks and dock strings are all made of steel components. Accompany that with subzero temperatures and water from the river and it is easy to see the difficulty in preventing slips, trips and falls along with difficult working conditions for workers as well as equipment. When the Upper Midwest experiences severe cold snaps, ice will develop on the rivers causing damage to vessels, barges, fleets and equipment. Dry docks are inoperable in these conditions as they accumulate heavy amounts of ice that damage vessels and even dry docks. Over the years, ice has done significant damage to towboats also resulting in fuel and oil spills that are very harmful to our rivers and environment.

High winds are another environmental impact that faces the maritime industry. Shipyards seem to deal with high winds on a daily basis that cause for treacherous wakes and conditions. Thunder storms are common on the river, especially the Mississippi River, and have also been known to develop into more serious conditions and even tornadoes. Shipyard workers perform normal duties throughout the day and night while in the rain, only shutting down during lightning and high winds. Cranes, telehandlers, and forklifts are all common equipment used in

shipyards that get shut down daily due to the winds and possibility of lightning. Anemometers are common instruments used on cranes and towboats to measure wind speed and direction. A written policy should be in place for operators and superintendents to determine operating procedures and critical lifts in winds at shipyards. Strong winds also have the ability to push an entire tow and the vessel pushing it into stationary objects situated on the river. Every year dozens of dams, railroad bridges and highway bridges are damaged by heavy winds pushing towboats and their barges into them.

Inclement weather and environmental impacts can place a severe strain on maritime activities across the industry from shipyard repair to river transportation. Companies are making great strides in the maritime industry to train and implement safety policies that protect shipyard and transportation workers from the hazards associated with inclement weather. The buddy system is always recommended during these situations at the dry dock and also on tugs where another worker or deckhand is never out of their coworker's sight.

Considerable Heights

The constant working at a considerable height puts shipyard workers at risk on a daily basis. Whether it is new construction or the repair side, workers are put in awkward body positions at different elevated levels. As towboats are dry docked, some vessel's wheelhouses can reach up to fifty feet high from the dry dock deck. As stacks are removed in order to repair engines and exhausts, workers are exposed to extreme heights that can lead to fatal incidents. Scaffolding, scissor, and man lifts are stationed accordingly all throughout the shipyard and employees should be trained on proper guardrail safety.

As scaffolding is erected at many different heights, it is to be installed and inspected by a scaffold competent person prior to each shift. Scaffolding shall not be used unless they are properly tagged with the current date and competent persons' initials. Normally green tags notify workers that the scaffold is properly erected and safe to use. Yellow tags inform workers that the scaffold is safe to use but has a special precaution such as a need for harness where a handrail system can't be used. Yellow tags are common due to the different transitions and corners barges and towboats have. Red tags or No tag means that the scaffold is not safe for use and should not be accessed at any time.

Screw jacks are common in shipyard scaffolding due to the work being performed from work flats that are not at the same elevation as dry docks. Screw jacks should never exceed 12" and guardrails shall be installed on all open sides of platforms more than 5' above the ground unless the front of the scaffolding is within six inches of the working surface.

Scaffolding should be fully planked all across the work area and scaffold boards should never be hung on the ladder rung sections of scaffolding. Although it is not a standard, it is best management practice to secure scaffolding anytime above 15' from the deck. A good example of securing scaffolding is welding a U-bolt to the boat or barge around the scaffold frame but never welding directly to the scaffolding. Many scaffolding incidents have happened in shipyards from high winds where a set of scaffolding was wrapped in plastic and not secured properly. If a scaffold is moved or altered, the competent person must inspect it again. It is important to replace any damaged scaffolding, encourage employees to be on the lookout for defects that may occur during operations, and to immediately notify their supervision. It is the responsibility of the safety department and supervision to instruct their workers on proper scaffolding techniques and to discipline employees anytime they are in direct violation.

Articulating boom lifts and scissor lifts are other types of equipment used in shipyards daily. Due to many different circumstances, these diesel or aerial lifts are useful for when working in those hard to reach areas and can help boost productivity. Employees must be trained and aerial lift certified on standard operating procedures for equipment along with proper fall protection. Workers are to be harnessed in all times while running man and scissor lifts unless extended over water.

Guard rails must be assembled when employees are exposed to unguarded edges of platforms more than 5ft. above a solid surface or water. When guard rails are omitted, shipyard workers must follow fall protection procedures and wear a harness. Many situations occur in shipyards where a section of deck is cropped out for repair or even to remove faulty equipment such as engines and pumps. During these times, a proper guardrail should be assembled using vertical supports no more than every 8ft. The guard rail should have a top rail at 42” and a mid rail at 21” with toe boards if necessary. Guard rails can be made out of lumber or rope unless hot work is exposed and then pipe, wires, or chain is recommended. Wire rope guard rails are used on barges while in shipyards to assist workers while working in separate wing tanks. These wire rope guard rails run longitudinal on each side deck of the barge and used for workers to harness into instead of constantly moving an extension ladder to enter tanks. Wire guard rails must be at least a ¼” in diameter and must be able to support the weight of a fall.

Many incidents have occurred in shipyards due to an employee falling into an unguarded hatch that was not properly marked. These falls can be fatal and severe due to the heights of barges, towboats, and even dry dock wing walls. Properly guarding each open man-hole cover with a safety yellow guard will help eliminate falls from open covers along with adequate lighting. Guards can be fabricated using expanding metal and rebar and should always be

labeled “*Caution Open Hatch*”. Safety meetings should be conducted while working on towboats because many doors open to the outside where an open hatch may be. It is the responsibility of the foreman on the job to notify the crew and to make sure they are aware of all open hatches on their vessel.

Slips, Trips, and Falls

Slips, trips, and falls continue to this day to be one of the leading causes of injury and fatalities in shipyards. Falls to a lower level account for 40% of all fatal shipyard accidents. Slip, trip, and fall injuries are the third leading cause of injuries that involve days away from work. (U.S. Bureau of Labor Statistics, 2012). Whether it is a fall from height or a simple trip these incidents can be very painful and costly and should be a focus of any shipyard safety program. OSHA regulations for protection from falls are outdated as 1915 subpart E has not been updated since 1971. This is an area where going above and beyond the regulations is a must.

Slips and trips occur from obstructed walkways, inadequate lighting, and even from wearing improper work boots. Preventing slips and trips in the shipyard will always be a safety manager’s worst nightmare. The repetitive walking on uneven surfaces in shipyards caused by stairs, ramps, deck fittings, and barges are all unhealthy hazards. Housekeeping is a major factor in slips, trips, and falls at shipyards due to the cluttering of welding leads, torch hoses, and extension cords that are all part of everyday activities. Good line management practices and running leads overhead when practical are important steps to keep the trip hazards from these to a minimum. Also making sure scrap and trash is removed from work areas is important to reducing housekeeping trip hazards. By its nature shipyard work is wet and can be slick.

Making sure walking surfaces have non-slip traction areas and stay as dry and clear from river debris is also a concern. Towboat's and tug's engine rooms are common places for slips, trips, and falls. The majority of engine piping on vessels includes oil, fuel, and water piping. All these lines are run below the engines under deck plates that are considered the bilge. As vessels come in for repair, engines are sometimes drained and lines are dumped off in the bilge. Cleaners and tankermen are prepped to clean these areas for the proper scope of work. This requires removing deck plates and walking in the proximity of slick and unsafe conditions. Each year many slips, trips, and falls occur in the lower engine room resulting in different injuries. Back and knee strains are common injuries that happen from wearing improper boots to even cutting corners and standing on uneven surfaces.

Falls also happen frequently in the shipyard industry and are mostly the result of human error and lack of proper training and equipment. Workers who aren't properly trained take unnecessary risk without knowing there is a safer way. They also get complacent to the hazards around them. It is important to insure that workers are provided quality personal protective equipment for fall protection and are trained in how to care for it and use it properly. It is also necessary that workers are trained in the fall hazards involved with their job task and how they can minimize the risk to themselves.

The first step in protecting from falls is to try to engineer out the hazard before work begins. If you can do the work without exposing workers to a potential hazard then you eliminate the potential for injury. If you can do a job on the ground instead of at height then it helps eliminate fall hazards. Also if you can install safety handrails to protect workers from a fall you minimize the potential of a fall. Properly installed handrails are one of the best ways to provide fall protection without limiting your workers. Making sure all holes are covered and

openings guarded is also required. The way to lay out a job task and set up the work area is important for controlling losses but sometimes a job can't be performed without a fall risk and fall protection devices such as harnesses and lanyards must be used. It is up to the foreman and safety department to discuss the work scope prior to unsafe conditions by filling out a Job Safety Analysis (JSA) or Job Hazard Analysis (JHA).

When shipyard employees are exposed to unguarded edges of deck, platforms, flats, and similar flat surfaces, more than 5ft above a solid surface or over water, the edges shall be guarded by adequate guard rails, unless the nature of the work in progress or the physical conditions prohibit the use or installation of guard rails. If putting up handrails is infeasible then fall protection devices such as a harness and lanyard or a personal flotation device if directly over water must be used. Harnesses must be inspected prior to use to ensure they are in good condition, and workers need to be trained in what to inspect for. Due to the majority of shipyard work being less than 18ft above, a lower level retractable lanyard should be used instead of a 6ft lanyard. Tie off anchor points need to be able to support 5,000 lbs and should be set up to avoid swing fall hazards. Proper training in how to use fall protection harnesses is very important because if worn improperly or anchored to something that will not support the worker, then he can still be severely injured in a fall. Training of workers and supervision on fall protection is key to its effectiveness because these systems do not offer full protection unless used properly.

Confined Spaces

It is the policy of all Inland River Shipyards to comply with the regulations contained in 29 CFR 1915 relevant to entry and work in confined spaces. In general, a confined space is any

space that has limited openings for entry and exits, and/or poor ventilation, which could contain or produce dangerous concentrations of air contaminants, combustible or flammable gases or vapors, a deficiency of oxygen, or also contain bulk or loose material that could engulf an employee. Workers at shipyards will spend almost as much time in confined spaces as out in wide opened spaces. The prime examples of confined spaces on towboats include fuel and ballast tanks, voids, sewage tanks, inner bottoms, and even a CO₂ protected small space in an instance where the system activated and the person present was unable to escape quickly. There have been many instances in shipyards where hot work in one space or area has caused fires and explosions in adjacent spaces due to the design of barges and towboats. Although each tank is vented to the atmosphere, some confined spaces are very hard to ventilate due to one entry hatch in breezeways on towboats. Confined and enclosed space incidents can be extreme and are the leading causes of fatalities in shipyards. According to OSHA, the rate of confined space injuries in shipyard environments, are twice those of general construction industry. Shipyard companies are learning to take appropriate actions to protect their workers and reduce the number of confined space incidents.

Fires and Explosions

Fires and explosions are the most severe hazard involved in confined and enclosed space incidents. 25% of fatalities in shipyards are the result from fires and explosions caused by hot work (U. S. Bureau of Labor Statistics, 2007). Explosions typically occur when gas and oxygen torch hoses are left in a tank while on break and a simple connection is leaking causing the

atmosphere to become oxygen enriched. Portable gas and oxygen cylinders are never allowed in a confined space along with propane heaters. Due to the nature of shipbuilding and repair work, many work hours are spent inside void tanks, wing tanks, and other confined spaces. Most work consists of cutting and fitting steel components while using gas and oxygen torch hoses. This is a routine job in many shipyards and all too often the hazards are overlooked, which results in senseless incidents that can easily be prevented by following proper safety practices. Pressure testing of gas and oxygen torch hoses every quarter and adequately marking them with color codes will help minimize incidents and protect employees. Paint vapors due to freshly coated tanks can also result in an ignition causing a fire or explosion in confined space and adjacent tanks. Welders must remove their electrodes from stingers any time they leave a tank to reduce the chance of a spark or ignition. Proper grounding is significant when performing any welding activities. Housekeeping plays an important role in eliminating fires due to the combustibles of rags and trash that accumulate in tanks. Fire watches are very important in today's shipyards and cannot be taken for granted. Each fire watch is designated to their specific tank and must always have two means of fire prevention that include an AFFF foamer and water hose. These AFFF foamers are to be checked and inspected prior to each shift before use.

Many incidents have happened throughout the country, especially in third world countries where sometimes safety is overlooked and not practiced. These incidents are costly to business owners and have the potential for extensive property damage and delays in business along with legal liability for any workers who have suffered injury. Due to the amount of serious injuries and fatalities along with rising workers compensation claims, companies have begun to employ safety professionals to develop written confined space plans and enforce safety policies and procedures to prevent future incidents.

Falls in Confined Spaces

Falls are also a leading cause of injuries inside confined spaces. Though the severity is less than that of explosions, the sheer number of injuries is alarming. Injuries are typically a result of slippery surfaces and inadequate lighting. These confined spaces typically contain diesel fuel or grease and must be cleaned thoroughly before hot work can commence. As workers are cleaning these spaces, they must pay attention to the raised floor angles and gussets which many times are hard to see due to the poor lighting. New battery and electric magnetic LED lighting have been improvised to assist with lighting in confined spaces. Many injuries occur as workers are traversing from one end of the tank to the other and step on a slick floor frame resulting in a muscle strain or contusion. Another issue shipyard workers face is limited means of entrance. Some of these voids can be very large however; the opening is a manhole that may only be eighteen (18”) inches wide. Ladders and manufactured scaffolding will not fit through the openings to the tank. If the job entails working at heights, job-built scaffold may be the only means to reach the work area. Workers are required to harness off of beam clamps that are fastened to deck angles and sometimes must weld their own eye clip for their anchor points. If the job-built scaffolding is not properly erected workers might be at risk from a fall as they perform work.

Hazardous Atmospheres

Hazardous atmospheres inside confined spaces are another common hazard associated with shipyard repair work. Many of the barges that transit the inland waterways are tank barges

that are commonly referred to as “Red Flag Barges”, these barges are specifically designed to hold various chemicals and liquids such as anhydrous ammonia or benzene. These specific barges are strictly regulated by the United States Coast Guard. When these barges come into shipyards they have potential to leak product from the cargo tanks into the wing voids creating toxic atmospheres. If proper safety practices are not followed, workers could be exposed to toxic atmospheres that would result in everything from respiratory distress to fatalities. Luckily these toxic atmospheres are usually predictable and preventable. They offer warning signs such as pungent smells or irritation to workers mucus membranes before ever entering the space.

Oxygen deficient atmospheres are one of the most common hazards associated with confined space work in shipyards. More often than not these void spaces have been closed up for months or even years with no ventilation. The oxidizations from rusting consumes the oxygen inside these tanks making levels less than 19.5% oxygen, therefore creating dangerous environments for workers to perform repairs. Most companies in the United States have taken proactive steps to prevent incidents from hazardous atmospheres such as hiring a marine chemist to certify the vessel prior to work being performed on any red flag barge. Companies are also required to perform an OSHA 74 form by a shipyard competent person at the beginning of each shift to verify each void on the vessel being worked has a safe atmosphere and is visually inspected before being labeled as safe for hot work.

Confined spaces will always be a part of day-to-day activities in shipyards. With new construction and repair of aging towboats and barges, shipyard workers constantly battle the poor conditions of confined spaces and adequate ventilation. Barges and towboats are all fabricated with many different tanks and voids that are considered confined spaces.

- Standard hopper barges are 35' wide, 195' long, and can be used to a 9' draft with a loading capacity of 1500 tons. There are approximately 26,000 dry cargo barges running our waterways today. Standard hopper barges are built with a bow rake compartment, a stern compartment, and up to four to five wing compartments on each side. Each tank is isolated with a bulkhead to separate wing tanks and also a longitudinal centerline bulkhead to separate port from starboard. All barges are built to withstand damage in individual tanks and still be able to float. Each compartment has a man-hole hatch for entry which are all considered confined spaces. Standard hopper barges take a beating throughout its lifespan and visit many different shipyards for repairs.
- Tank barges are constructed to carry liquid, solid or gaseous commodities in bulk all across the inland river waterways and are marked and known as red flag barges. They range in size from 35'-54' wide and up to 150'-300' long. Tank barges normally have three separate cargo tanks with a capacity of 30,000 barrels of product. Each red flag barge is built a bow and stern with wing voids that like the cargos, are all considered confined spaces. These tank barges are fabricated with double hulls which mean that if a cargo tank is damaged, it will leak into an adjacent void instead of dispensing in the river. Tank barges are an everyday part of shipyard repair and inspection. Each red flag barge must have an Internal Structural Examination (ISE) completed two times in a five year span and a cargo header test completed each year from a shipyard for a Certificate of Inspection (COI) given by the Coast Guard. A cargo tank internal inspection and dry docking must be kept up to date every five years along with ultra sonic gauging. Prior to entry on an empty tank barge, a certified Marine Chemist must check the oxygen and

lower explosive limits (LEL) levels along with visuals and issue a safe for entry gas free certificate. If the cargo or wing tanks require cleaning, the Marine Chemist will have to come back and issue a safe for hot work gas free certificate. The Coast Guard will then be notified and a work scope proposal will be discussed for all damage repairs. Tank barges will always be efficient to shipyards due to the regulations and mass number of barges running the waterways. The majority of work consists in confined spaces on tank barges and will always be dangerous to workers if preventive loss control is not practiced and maintained.

- Towboats range from many different widths, lengths and heights and account for many confined and enclosed spaces. Each specific tank on a towboat is considered a confined space while engine rooms and rudder rooms are recognized as enclosed spaces. Some towboats have the capacity to hold over 200,000 gallons of fuel that is separated by anywhere from five to six tanks on the port and starboard sides of the vessel. Each tank is separated with a bulkhead to isolate each tank but normally is piped through each other to transfer fuel. Ballast tanks also account for a lot of holding ability on a towboat and can accumulate over 200,000 gallons of water. Ballast tanks are filled on towboats to assist with stability while shoving a tow. Water tanks consist of potable and wash tanks that the crews use for drinking and showering purposes. There are many different oil tanks positioned across towboats that supply and return hydraulic, gear, and lube oil for main engines, gear boxes, and steering. Slop and dirty oil tanks are used by engineers to hold oily mixtures and sludge taken from engine room bilges and other dirty oil mixtures. Overboard drains and piping that run throughout tanks are leaking due to

aging and being replaced with stainless steel. Each one of these confined space tanks is crucial to towboats and shipyard repair.

Over the years many confined space incidents and fatalities have resulted from a rescuer entering an oxygen deficient or toxic atmosphere to save a friend or co-worker. Even when properly trained, workers forget their training and personal protective equipment and immediately disregard proper entry procedures to rescue a co-worker because they are overcome by natural emotions. Although shipyards are required to have written procedures and programs related to confined space entry, it does not release the company from liability due to an employee's disregard of their procedures.

Each shipyard is required to develop and train their own confined space rescue team. Each shift should have its own team consisting of at least five members, which are two entrants, two standbys, and one incident commander. Each employee assigned to the team should be competent person trained and familiar with the proper PPE used for rescue operations. They should also be aware of respirators and the common rescue equipment necessary to perform rescues from confined and enclosed spaces with dangerous atmospheres. Tripods are a common rescue tool used in shipyards due to the use of man-hole entries in barges and towboats. Being skilled on the proper use of harnesses and lanyards also benefit with strapping techniques on stretchers. Shipyard rescue teams should have annual refresher training along with practice drills throughout the year using mannequins and real life situations in shipyards. It also benefits if certain members maintain certifications in basic first aid and CPR.

Marine Chemist

Marine Chemist are specialists certified from the NFPA (National Fire Protection Association) to determine safe entry and hot work within confined spaces of marine vessels and barges in shipyards that have contained flammable or combustible materials.. Marine Chemists are an important factor of day to day activities in shipyards. They are required to give a gas free certificate before hot work or fire producing operations can be carried out in certain spaces aboard a marine vessel or red flag barge. The Marine Chemist is called upon after a towboat, tug, dredge, or red flag barge enters a facility. Each confined and enclosed space will be inspected and metered for entry. The Marine Chemist will designate whether the spaces are: *Atmosphere Safe for Workers, Not Safe for Workers or Enter with Restrictions, Safe for Hot Work, and Safe for Limited Hot Work.*

Atmosphere Safe for Workers means that the oxygen content of the atmosphere is at least 19.5% and not greater than 22% by volume. The concentration of flammable materials is below 10% of the LEL. Any toxic chemicals in the atmosphere associated with cargo and adjacent spaces are within permissible concentrations at the time of inspection. It also states that the remaining chemicals in a certified space are not capable of producing toxic materials that exceed permissible concentrations. After the tanks are declared safe for workers, pumping and cleaning operations begin for a hot work permit.

Not Safe for Workers indicates that the space shall not be entered by any personnel. This shows that the oxygen content, LEL, or toxic chemicals are present and ventilation should begin for at least thirty minutes before metering again. *Enter with Restrictions* means that entry should be permitted only if conditions of PPE, clothing, and time are specified. *Enter with Restrictions*

is not intended to apply to spaces with IDLH atmospheres unless it is for an emergency rescue or to install ventilation equipment.

Safe for Hot Work certificates are mandatory for shipyard repair. This certificate states that the oxygen content in the space is not greater than 22% by volume and the concentration of flammable materials in the atmosphere is less than 10% of the LEL. It also declares that all residues in the tank and on framing have been cleaned sufficiently to prevent the spread of fire or producing a higher concentration than permitted. The gas free certificate will also include maintaining mechanical forced air ventilation and posting a fire watch in hot work areas at all times.

Safe for Limited Hot Work can also be noted by the Marine Chemist and describes specific locations in spaces when an adjacent tank may not be gas freed and hot work can only be done within 1ft of any uncertified space. It also states that piping running through any uncertified space bulkheads cannot be welded on.

Inerting tanks for hot work occurs on towboats and red flag barges in shipyards and can only be done with the assistance of a Marine Chemist. Towboats and tank barges bring diesel and oil tanks into shipyards with fractures that require immediate and sometimes quick repairs. Fractures include a loose frame or deck fitting that needs to be reattached without removing the product and cleaning the tank. The Marine Chemist will use sufficient volumes of carbon dioxide to maintain the oxygen content of the atmosphere of the space at or below 6% or 50% of the amount required to support combustion, whichever is less. The Marine Chemist will then monitor the hole and recommend time when it is safe for repairs. The Marine Chemist will then

standby until the scope is completed and measure safe disposal of the inert gas. Closing and securing of hatches except vents shall be permitted to be used as safe disposal.

In conditions where potable and wash water tanks are coated and only have one hatch for entry, the Marine Chemist can allow a tank to be filled up to the vent with water to eliminate a fire from beginning. This occasion happens quite frequently because many deck fittings such as roller chocks and kevels get damaged and are stationed over coated water tanks.

Most Marine Chemists are independent contractors that travel all across the country to different facilities while some shipyards have come in to conclusion to hire their own personal Marine Chemist. Due to the extent of long term projects in shipyards, a marine chemist may write many different gas free certificates for a certain towboat or vessel. As work scopes increase and tanks are being pumped and cleaned, a Marine Chemist can be called upon twice a day on projects and may write up to ten different certificates throughout the course of repairs. Overlooking safety and cutting corners by not using Marine Chemist have led to many fatal incidents in private owned shipyards all across the country.

The following page shows a copy of a Marine Chemist certificate. The certificate should be dated with the accurate time the vessel or barge was surveyed. The certificate will also have the Marine Chemists' name printed and signed with his contact information. It details the vessel type, company, and scope of work. It also lists each individual tank and void from port to starboard that will be entered along with the special instructions given by the Marine Chemist prior to any hot work. A copy of the Marine Chemist certificate must be posted in a mailbox prior to stepping on the drydock or taped on the vessel's engine room door for observation or inspections by the USCG.

MARINE CHEMIST CERTIFICATE

Marine Chemist's Name: Marine Chemist # 1
(Print)

SERIAL NO. **A**

Marine Chemist's Contact Information: XXX-XXX-XXXX
(Telephone/Pager/Email)

Page 1 of 1

Survey Requested by: Murray State Vessel Owner or Agent: Shaw Enterprises Date: 2/1/19
 Vessel: M/V Roger Shaw Type of Vessel: Tug Boat Specific Location of Vessel: Murray, KY
 Last Three (3) Loadings: Diesel (X3) Tests Performed: O₂, LEL, Visual Time Survey Completed: 0905

Scope: Wheels, rudders, shafts

	<u>%O₂</u>	<u>%LEL</u>	<u>Visual</u>
<u>Pisthd Stern Voids</u>	<u>20.9</u>	<u>0</u>	<u>OK</u>
<u>Fwd Stern Void</u>	<u>20.9</u>	<u>0</u>	<u>OK</u>
<u>Rudder Room</u>	<u>20.9</u>	<u>0</u>	<u>OK</u>
<u>Bow Void</u>	<u>20.9</u>	<u>0</u>	<u>Water</u>

*Atmospheric Safe for Workers
*Safe for Hot Work

*Maintain mechanical forced air ventilation work tanks/spaces
No hotwork within 1ft of uncertified spaces h/k/hds
All adjacent /uncertified tks to remain closed and secured. (Fuel tks)
Post-fire watch in hotwork areas IAW 29 CFR 1915 Sub Part P.
Local shifting permitted

In the event of physical or atmospheric changes affecting the STANDARD SAFETY DESIGNATIONS assigned to any of the above spaces, this certificate is voided; spaces not listed on the Certificate are not to be entered unless authorized on another Certificate and/or maintained in accordance with OSHA 29 CFR 1915; or if in any doubt, immediately stop all work and contact the undersigned Marine Chemist. Unless otherwise stated on the Certificate, all spaces and affected adjacent spaces are to be reinspected daily or more often as necessary by the competent person in support of work prior to entry or commencement of work.

QUALIFICATIONS: Transfer of ballast, cargo, fuel, or manipulation of valves or closure equipment tending to alter conditions in pipelines, tanks, or compartments subject to gas accumulation, unless specifically approved on this Certificate, requires inspection and a new Certificate for spaces so affected. All lines, vents, heating coils, valves, and similar enclosed appurtenances shall be considered "not safe" unless otherwise specifically designated. Movement of the vessel from its specific location voids the Certificate unless shifting of the vessel within the facility has been specifically authorized on this Certificate.

STANDARD SAFETY DESIGNATIONS: (partial list, paraphrased from NFPA 306).

ATMOSPHERE SAFE FOR WORKERS: In the compartment or space so designated (a) the oxygen content of the atmosphere is at least 19.5 percent and not greater than 22 percent by volume; (b) the concentration of flammable materials is below 10 percent of the lower explosive limit; (c) any toxic materials in the atmosphere associated with cargo, fuel, tank coatings, inerting mediums, or fumigants are within permissible concentrations at the time of the inspection.

NOT SAFE FOR WORKERS: In the compartment or space so designated, entry is not permitted.

ENTER WITH RESTRICTIONS: In the compartment or space so designated, entry for work is permitted only if conditions of proper protective equipment, or clothing, or time, or all of the aforementioned, as appropriate, are as specified.

SAFE FOR HOT WORK: In the compartment or space so designated (a) the oxygen content of the atmosphere is not greater than 22 percent by volume; (b) the concentration of flammable materials in the atmosphere is less than 10 percent of the lower explosive limit; (c) the residues, scale, or preservative coatings are cleaned sufficiently to prevent the spread of fire and are not capable of producing a higher concentration than permitted by (a) or (b); (d) all adjacent spaces, containing or having contained flammable or combustible materials shall be sufficiently cleaned of residues, scale, or preservative coatings to prevent the spread of fire, or they are inerted. Ship's fuel tanks, lube tanks, or engine room or fire room bilges, or other machinery spaces, are treated in accordance with the Marine Chemist's requirements.

SAFE FOR LIMITED HOT WORK: In the compartment or space so designated (a) portions of the space meet the requirements for Safe for Hot Work and Partial Cleaning, as applicable, or (b) the space is inerted, adjacent spaces meet the requirements for Safe for Hot Work, and hot work is restricted to specific locations; (c) portions of the space shall meet the requirements for Safe for Hot Work, as applicable, and the nature or type of hot work is limited or restricted.

NOT SAFE FOR HOT WORK: In the compartment or space so designated, hot work is not permitted.

CHEMISTS ENDORSEMENT. This is to certify that I have personally determined that all spaces in the foregoing list are in accordance with NFPA 306 Control of Gas Hazards on Vessels and have found the condition of each to be in accordance with its assigned designation.

"The undersigned acknowledges receipt of this Certificate under NFPA 306 and understands conditions and limitations under which it was issued, and the requirements for maintaining its validity."

This Certificate is based on conditions existing at the time the inspection herein set forth was completed and is issued subject to compliance with all qualifications and instructions.

Signed Roger K. Shaw Murray State 2/1/19 Date Signed Marine Chemist #1 CMC-XXX Certificate No.

POSTING COPY

Printed in U.S.A.

Figure 3, Marine Chemist Certificate, James Marine Inc.

Shipyard Competent Person

Shipyard competent persons are trained individuals who are able to understand the directions and instructions left by the Marine Chemist. All shipyard competent persons are designated for training by marine management. In order for the certificate to be maintained, the competent person must inspect all confined and enclosed spaces documented on the gas free certificate including all adjacent spaces, piping, and valves. Each competent person holds a special certificate given to them after taking a course given by a certified Marine Chemist or certified industrial hygienist. A designated shipyard competent person has the responsibility to inspect every tank the Marine Chemist noted on their gas free certificate and visually inspect the surroundings for any equipment close by. Prior to each shift, this competent person must check the space for its oxygen content and lower explosive limit (LEL) levels with a calibrated and reliable gas detector. If a compartment is found not safe for entry, they must immediately notify supervision and stop work immediately. Shipyard competent persons are to be adequately trained in calibrating meters and proper ventilation techniques. A confined space OSHA 74 log must be filled out at the beginning of each shift prior to entry and repair on any marine vessel or barge in shipyard facilities by a certified competent person. These OSHA 74 logs must be available for observation by the USCG prior to inspections on towboats or red flag barges and must be filed until upon completion of repairs. In an event where there are multiple people performing hot work in a confined space, the competent person and supervision will allow continuous monitoring to determine that air concentrations are within the permissible exposure limit (PEL) and below immediate dangerous to life or health levels (IDLH).

Hot Work

Hot work in shipyards involves any work using brazing, welding, cutting torch, or any other spark producing tools such as grinders that produce a source of ignition. Any of these common day to day operations that raise the temperature of the work piece equal to or greater than 204 degrees C or 400 degrees F is considered hot work. Hot work is prohibited on any marine vessel or tank barge until a gas free certificate is issued by a Marine Chemist or inspection by a competent person. Hot work increases the risks of fires and explosions in shipyards due to the majority of it being conducted in confined and enclosed spaces. It also presents potential hazards if adjacent spaces are not properly prepared and cleaned. Asphyxiation, inhaling toxic fumes, burns, and eye injuries are all potentially serious hazards associated with hot work.

The majority of work in shipyards today is considered hot work. Whether it is new construction or the repair side of shipyards, sparks and flames are consistently flying from cutting torches and welders. It is up to the foreman to coordinate the scope of hot work in close proximity to other workers. Workers welding and cutting in the same tank or void must maintain awareness of each other and keep a reasonable distance from each other to minimize sparks, splatter, and the risk for flash burn. It is also very important to clear the area below cutting operations to keep from dropping hot slag on hoses, cables, and other employees.

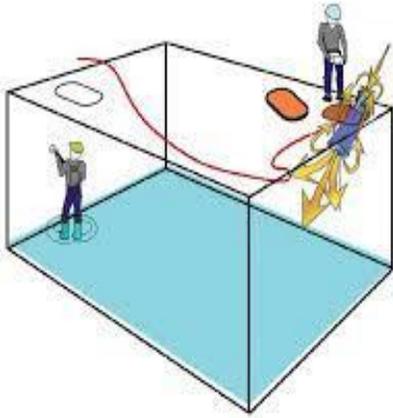
Fire watches are very important and must be posted when cutting within 25ft of flammable and combustible materials or when required from the gas free certificate. Boosting awareness and providing employees with the proper PPE will help minimize fire related incidents and burns.

Ventilation

Far from other station based welding tasks; shipyard workers perform hot work in a variety of spaces that make it difficult to properly implement engineering controls, such as ventilation. The continuous work in confined and enclosed spaces restricts natural air movement and increases exposures to welding fumes. Hazardous air contaminants come from residue that was previously in the tank or from contaminants given off from welding or other hot work procedures.

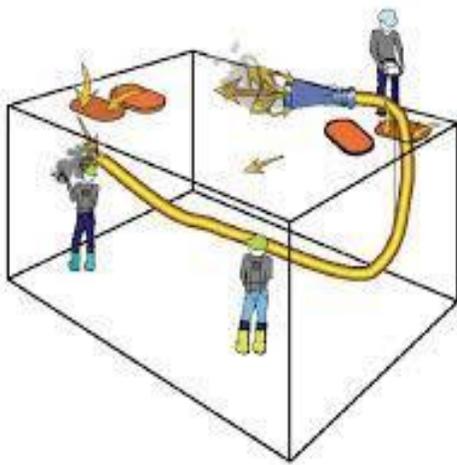
Adequate ventilation must always be set up while working in confined and enclosed spaces. Duct work to the point of hot work in order to remove the fumes can be achieved by dilution ventilation and local exhaust ventilation. Dilution ventilation is the process of forcing large amounts of supplied air to the space. Local exhaust ventilation captures smoke and contaminants at their point of origin and removes them. As both of these types are commonly used in shipyards, plastic duct is available in rolled sections that easily remove the contaminants from boats and barges to safe areas.

Axial industrial electric fans are the most common fans used for ventilation in shipyards. The ability to use duct or hoses from these fans makes it very easy for workers in hard to reach areas. Pneumatic blowers or air horns are also used in shipyards and help ventilate confined spaces with compressed air. The concept of setting a fan over a hole and turning it on is not acceptable for proper ventilation. In order to ensure proper ventilation, air flow must be projected to the point of operation. By doing so, it limits the amount of exposure a worker is exposed to because of the frequent air changes. Ventilation systems must have an adequate CFM rating for the size of the confined space shipyard workers are performing tasks in.



Improper Ventilation

- The illustration to the left exhibits a poorly ventilated confined space. The duct work should have been run to the point of hot work for the worker, and the second access hatch should also have been removed to circulate more fresh air. Although the tank is being monitored, it still shows an improperly ventilated tank.



Proper Ventilation

- The next illustration demonstrates proper forced air ventilation techniques in a confined space. Both hatches are open for air flow and local exhaust ventilation could also be used by turning around the fan. The buddy system is being practiced along with proper testing and monitoring of oxygen levels.

Figures 5 and 6, Improper and Proper Ventilation.

<https://www.osha.gov/Publications/OSHA3639.pdf>

Lockout and Tagout

Energy sources that include electrical, mechanical, hydraulic, pneumatic, chemical, thermal or other energy sources can be hazardous and lead to many accidents. Lockout and tagout is a key safety component in shipyards and is used every day on towboats and red flag barges. Without properly isolating the source by lockout and tagout procedures, servicing machinery and equipment can result in employees being smashed and electrocuted. The proper use of communication, training, along with a written procedure should be implemented by the safety management team. This communication should also be relayed to contractors in shipyards as they are required to comply with each facility's standard. As towboats are being docked in shipyards, proper lockout and tagout procedures should begin with an authorized employee and the chief on vessel. Main engines and generators are to be locked out at the air source to prevent starters from turning over while fuel supply lines may also be used as a backup lockout source. Hydraulic ram systems are very dangerous and have led to many smashed-by incidents in rudder rooms and underneath the vessel due to poor communication. It is also mandatory to shut down a vessel's radar and properly lock them out when they enter a shipyard as they are known to release radiation. Fuel line valves are to be locked and secured while isolating fuel from separate tanks. In some circumstances, fuel tank repairs consist of shipyard workers cleaning a tank while an adjacent tank may be full of fuel. The supervisor of that dock and chief engineer on the vessel must work together to make sure all crossover and suction lines are shut and properly tagged out to prevent any run back of fuel on any workers.

It is the best interest for shipyards that the source or device on a vessel is properly locked and tagged out with a lock from the engineer on the vessel and a lock from the authorized

shipyard worker to prevent inadvertent startup. The concept of two locks will assist in communication and never allow a device to be turned on without ensuring that all employees have been safely positioned in the clear. Tags should be used to identify the type of service being conducted with the authorized worker's names and dates on it. Lockout and tagout forms are very helpful with maintaining your equipment, and these logs should be kept in a safe place until the project is complete.

Improper energy isolation will always be a major hazard in shipyards due to lack of training and awareness from employees. However, with an ever improving safety culture and greater emphasis on proper training in shipyards, the amount of injuries related to improper lockout/tagout procedures should be greatly reduced in the future.

Electrical Hazards

There is a great potential for electrical shock hazards in shipyards due to the constant work on metal and wet conditions. Electricity has the capability of causing employee injuries and extensive property damage. Electrocution, burns, or electrical shock are all types of injuries that may occur from working with energized electrical equipment. Electrical shock also has the potential to produce falls from different levels that can cause serious injuries.

Maintaining preventive measures for electrical safety is the responsibility of every employee in a shipyard. Damaged extension cords should be taken out of service immediately and taken to the electrical department for repair or disposal. Temporary lighting systems should

be checked prior to each use for any open sockets or missing protective cages that can cause burns and shocks. Welding machines repairs and maintenance are only performed by the electrical department and all leads and grounds should be inspected for good working order. It is up to the electricians that all panels and breaker boxes are marked and able to be accessed at all times.

The two sources of electrical power used in new construction and repair in shipyards comes from shore side and a vessel's generator. Each vessel is required to have a diesel generator online that feeds their main switchboard and an auxiliary generator for backup emergency situations. As towboats are dry docked or brought in for topside repair, electricians are on standby to swap the power source from generator to shore power. Only the electric department is authorized to modify, connect and disconnect shore power connections. This process consists of two electricians and proper lockout/tagout procedures at the electrical knife disconnect. Disconnects must be off when plugging in or unplugging shore power from a vessel and properly coordinated with the foreman on the job, electrical department, and chief on the vessel. Communication with outside contractors is very important to prevent inadvertent startup of pumps and other machinery.

Proper communication and electrical maintenance awareness makes for a safer workplace in shipyards. Providing employees with the proper PPE such as rubber mats and insulated tools will reduce the risk of electrical injuries in the workplace. Shortcuts should never be taken while dealing with electricity. Voltage tests will help identify an energized source while testing or troubleshooting a piece of equipment or system. Assured grounding programs are also being developed to prevent electrocution by ensuring the grounding wire is electrically continuous from the power tool to the power source for protection of employees.

Rigging

Rigging is when workers prepare equipment to be lifted by cranes, hoist, or other material-handling machinery and is a common work process in shipyards. Performing rigging operations safely is critical and many shipyard workers have been injured and killed when loads have slipped or rigging has failed.

Riggers and operators must be trained in the responsibilities for inspecting rigging and material handling equipment on an annual basis with records kept and available upon request. Prior to beginning a specific lift, the crane operator and rigger will need to determine how the lift is to actually be made. They will determine the weight of the load and capacities of the crane. Rigging personnel should also be trained to take proactive measures in case of unsafe conditions. This includes stopping operations in the change of wind and weather conditions and if they believe the lift may be compromised or may lead to an injury or unsafe act. Standard crane signals should be used and only accepted from one authorized person. Tag lines are mandatory when it is a necessity to control the load in tight areas, or the material being lifted needs to be guided away from hazardous areas.

In the event of a large lift where you might exceed 65% of the crane's capacity or there is a need for two cranes to lift a load in tandem, a critical lift checklist is filled out during the pre-lift safety briefing. This allows all operators and other critical personnel to have a common understanding of how the lift will occur, the type of rigging being used, and the supervisor who will be making all of the decisions.

There are many different types of rigging used in various shipyards and they must all include a tag from the manufacturer that specifies the lifting capacity.

- Chains are the most familiar types of rigging due to its superior strength and durability. They are stationary on cranes and cherry pickers and must always have hooks with safety latches. Chains should be inspected before each use to make sure any links aren't bent or elongated. There should never be any evidence of heat damage or weld splatter and must also be replaced if a tag is missing.
- Chain falls range from 1 to 15 tons and are a key necessity in shipyard repair. Chain falls are used primarily to maneuver parts in and out of towboats and for securing the addition and removal of steel on barges. Chain falls should be visually inspected prior to each use and load tested on a quarterly basis by certified facility personnel. The upper hook must always be latched to keep it from coming free from its support whether it is a welded eye clip or type of beam clamp. Electric and manual chain falls are used in shipyards; however, manual chain falls are the preferred method due to their smaller size and weight. Most shipyards only consider using 3-ton or above chain blocks to keep from being overloaded and for the safety of their workers.
- Nylon and wire rope slings are also common lifting devices used in shipyards and range from many different widths and lengths. These slings can be used for a vertical lift, basket or cradle lift, and even used a choker to secure an object for lifting. Rope slings should be taken out of service if the wires have any kinking or bird caging noticeable. Nylon slings should be stored in a dry place out of the weather and never used if there are any tears or stitching damaged. If a knot is in any part of the sling or the tag is not readable, the sling should be tagged out and replaced immediately.
- Spreader bars are used primarily in shipyards for the use of removing or installing engines and generators. Homemade spreader bars are never allowed. Spreader bars

should be designed by engineering guidelines and incorporate a safety factor 1-1/2 times the safe working load limit. Spreader bars should be clearly stenciled and taken out of service if ever bent or damaged. All spreader bars are to be inspected thoroughly before each use and load tested on an annual basis.

- Vertical plate dog clamps are used in shipyards daily to remove and transport steel to and from vessel and barge projects. These vertical clamps should be inspected before and after each use. Tag lines are always required while lifting steel as wind speeds and directions change.
- Metal mesh slings are used in machine shops to move tail shafts and stocks around to different machines and equipment. Metal mesh slings should always be centered and properly measured on the round bar for equal lifting procedures. Mesh slings are very simple to use and should be replaced if any visible distortion is noticed.
- Round slings are used where loads must be protected from damage. Round slings are normally made from polyester and enable the user to rotate the hook and contact points for proper lifts. Round slings also require a tag and should never be used in a knot.
- Shackles are used everywhere in shipyards primarily for connections of slings, chains, and blocks. Anchor shaped and D-shaped shackles are the two common used and are either a screw pin or bolt type pin. Bolt type pins should always have a cotter pin for safety to keep the nut from backing off. These shackles should be marked for tonnage and range from different sizes. They should be tagged out and disposed if they have any weld on them or have been heated and formed.

Long Term Effects of Shipyard Employment

Although many shipyard workers have made long successful careers with their trade, shipyard employment in the past has been linked to several long term health effects for workers. These include chemical hazards such as exposure to asbestos, paints, and welding fumes. It also accounts for many physical hazards such as noise exposure, extreme temperatures, vibration, awkward body positions, and the risk of repetitive motion injuries. One of the major long term concerns is chronic respiratory illnesses and cancers; particularly among workers exposed to heavy metals and workers who have a history of exposure to asbestos. Of the physical hazards with long term risk, hearing loss stands out in shipyard work. The following three topics will discuss some potential hazards shipyard workers are faced with on a routine daily basis.

Exposure to Heavy Metal Fumes

Many shipyard workers have potential exposure to fumes from hot work on a regular basis; without proper ventilation and controls over exposures can happen. Acute exposure to welding fume and gases can result in eye, nose and throat irritation, dizziness, nausea, and metal fume fever. Metal fume fever is a flu like illness caused by galvanized welding exposure to zinc oxide, magnesium oxide, or aluminum oxide fumes; it can also come from brazing and soldering due to exposure to lead, zinc, copper or cadmium. This flu like effect can last 24 to 48 hours after exposure. Also gases such as helium, argon, carbon monoxide and carbon dioxide displace

oxygen in the air and can be an *asphyxiation* hazard, particularly when welding and cutting in confined or enclosed spaces.

Long term health effects from certain fumes may include stomach ulcers, kidney damage, and nervous system damage. Prolonged exposure to manganese fume can also cause Parkinson's-like symptoms. Long term overexposure to welding fumes may also cause lung damage and various types of cancers, including lung, larynx, and urinary tract. Hexavalent Chromium from working with stainless steel is a particular long term health risk, and exposure levels are regulated by OSHA. Hexavalent Chromium fumes are highly toxic and can damage the eyes, skin, nose, throat, and lungs as well as causing cancer. OSHA's Permissible Exposure Limit (PEL) for Hexavalent Chromium is $5 \mu\text{g}/\text{m}^3$ as an 8-hour time-weighted average. Siderosis is another long term illness connected to welding. Siderosis is a pulmonary disease caused by long term repeated inhalation of iron oxide dust and fumes. This disease doesn't always show notable symptoms but it does increase the risk for lung conditions like Chronic Obstructive Pulmonary Disease (COPD) and Emphysema.

The best protection for welders and fitters is good ventilation by keeping a good supply of fresh air and moving the fumes away from the workers. This cuts down on the chances for exposures significantly. This is very important when doing hot work in enclosed or confined spaces where there is limited air movement to begin with. Exposures can also happen outside if there is enough welding being done to concentrate fumes in a specific area. If over the permissible exposure limit levels cannot be engineered out then use of respiratory PPE is required.

Asbestos

Historically, Asbestos exposure has accounted for a large amount of shipyard deaths. In the 1990's shipyard work was the number two industry listed for asbestos related deaths. Retired workers who worked in shipyards from the 1940's till the late 1970's are at the highest risk for Asbestosis and Mesothelioma. Older shipyard workers have exposure rates several times higher than in other industries at the time. Asbestos became highly regulated in the early eighties and exposure risks have gotten progressively better since. It was easy to determine that everyone who worked in the shipyard industry was put at risk and exposed to it from one time to another.

Asbestos was used in all areas of vessels due to its fire retardant abilities and was very common in engine rooms as a heat insulator for boilers and pipes. Asbestos was so common that it was also mixed with the paint that covered the ships, flange gaskets and friction control devices, floor or ceiling tiles, and even coatings for welding rods. It was believed that every aspect of the shipyard including the office buildings, machines shops, and even break rooms contained asbestos products. While regulated now, it is still an issue for shipyard personnel. Exposure hazards are very common as it is still used for insulation in the river industry where older vessels are constantly being kept up and remodeled instead of being replaced by newer built vessels. Repairs and updates on these vessels can cause this older asbestos to become friable. At this time testing and professional abatement of asbestos on vessels is common in the industry but, exposure dangers still exist due to just how wide spread its usage was. Independent contractors are being brought in with proper trained personnel to aide in the removal to help the safety and well being of employees. Current shipyard workers are still at risk and awareness and testing programs are necessary.

Noise-Induced Hearing Loss

Noise-induced hearing loss limits a worker's ability to hear high frequency sound. Noise-induced hearing loss is a permanent hearing impairment that results from prolonged exposure to moderate levels of noise. Exposure to noise is dangerous to a worker's safety and productivity. This can lead to misinterpreted workplace conversations and several health risks. Hearing loss can impact an employee with increased stress levels, high blood pressure, fatigue, and even cardiovascular events. The failure to interact in a social environment due to hearing loss can also lead to depression and anger. Those affected by hearing loss will not even find out until later in life after finding it hard to conduct a simple conversation. Hearing aids may help on some levels but this kind of hearing loss is permanent and cannot be corrected by medical means. It is estimated that close to \$250 million a year is spent on workers' compensation for noise-induced hearing loss. It is also preventable with a comprehensive hearing conservation program and proper PPE usage.

Exposure to loud noises can lead to short term hearing loss and tinnitus; repeated exposure can lead to the effects becoming permanent. Exposure to high levels of noise also increase mental stress in workers and increases the risk of accidents at work. Noise around 85 decibels can damage hearing after repeated exposures lasting 8 hours or more, 95 decibels can potentially do hearing damage in less than an hour of exposure. Unprotected exposure to noise of 120 decibels or greater may cause immediate hearing damage. There has also been a correlation found between high exposure to some metals and solvents that can exacerbate hearing loss from high noise exposure that must be taken into account too (McPhillips, 2017.)

As more and more companies are experiencing lost revenue due to the increased amount of worker's compensation claims associated with job related hearing loss, it has forced companies to implement a hearing conservation plan. A comprehensive hearing conservation program is needed in shipyards to protect against hearing loss in workers. This will include: audiometric testing of new hire workers to achieve a baseline with yearly hearing exams to look for signs of hearing loss, noise monitoring of shipyard areas for possible exposures over a time weighted average of 85 dBA, training for workers on the need for and proper use of hearing protection, and a program for trying to reduce workplace noise through the hierarchy of controls. Setting effective workplace rules and having a good hearing conservation program can go a long way towards eliminating noise-induced hearing loss.

Hearing protection is a serious and growing health concern that is consistently overlooked in today's world. However, in third world countries where they do not have Occupational Safety and Health Standards, workers still suffer a disproportionate amount of hearing loss from exposure to occupational noise in comparison to developed countries. Unfortunately, developing countries who do not have occupational safety standards have nothing to hold employers accountable for when it comes to safety practices, so one can only assume the trend will continue when it comes to occupational hearing loss and other hazards these employees are subjected to in the workplace.

The constant use of chipping and sledge hammers, working with 125 PSI of compressed air, and along with working in confined spaces with grinding going on at adjacent bulkheads is a leading cause of hearing loss in shipyards. Prevention is the first and most important step by

employers to protect their workers. The following diagram shows how using the Hierarchy of Controls can help minimize and eliminate exposure to noise in shipyards.

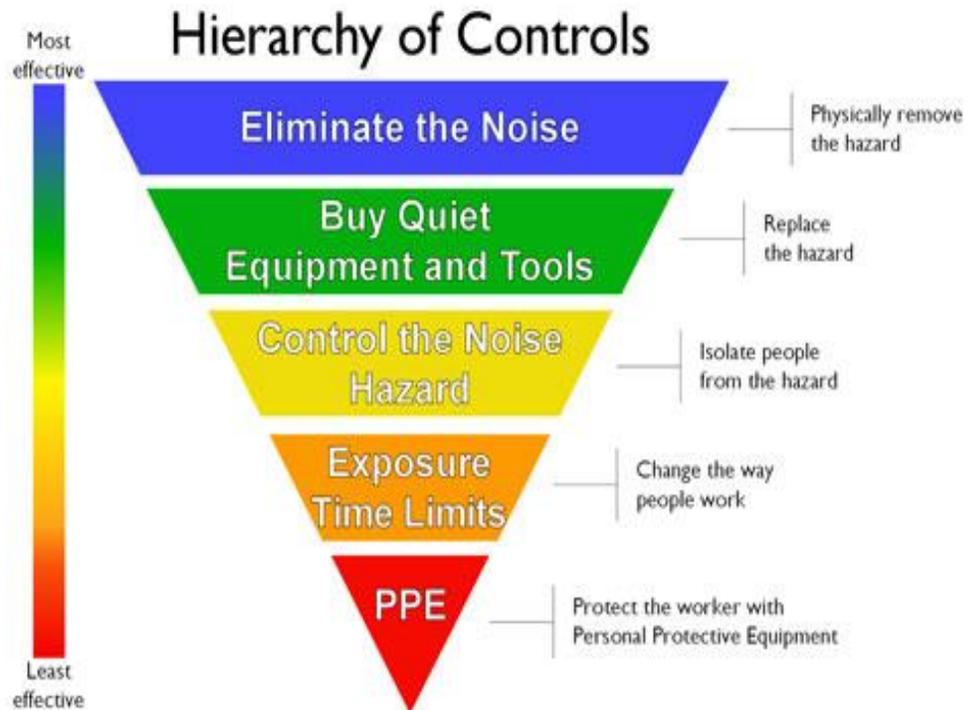


Figure 7, Hierarchy of Controls.

<https://www.cdc.gov/niosh/topics/noise/reducenoiseexposure/noisecontrols.html>

Prevention

Prevention is the first and most important phase in mitigating incidents in shipyards. Shipyards are learning that taking corrective measures before accidents happen and approaching long term health issues in the beginning will result in a safer and more efficient work environment. Preventive loss control is a team effort, but with the help of employees that care for their health and well being, it simply creates a better relationship within the company. Some shipyards are also experimenting with innovative strategies such as zero incident projects at the early project development stage to boost awareness with their employees. This strategy has been very successful in long term projects that include the shipyard workers, crews on the vessel, and each individual contractor involved. Upon completion of the project, incentives such as meals and shirts are given to show the appreciation and success given by each worker.

Hazard Recognition

A Job Safety Analysis (JSA) is a pre-job safety meeting quality tool developed to provide guidelines by identifying the job, management tasks, and recognizing hazards which are essential in any continuous improvement process. As much as shipyard repair is repetitive to experienced personnel, it still gives the dock foreman the opportunity to address any hazards prior to work beginning and promoting safety with his crew; especially new employees. The JSA should name the barge or vessel that the repairs will be on along with a description of the work scope. All PPE should be listed and checked off if required. Each step necessary to complete the job shall

be discussed with the potential hazards workers will be faced with. All JSA's will be signed by the foreman and workers and be kept on file for further discussions. JSA's will assist supervision and the safety department on eliminating hazards in the future and will help develop more effective work methods. It is management's responsibility to follow up and correct any uncontrolled hazards identified in order to maintain a safe work place. JSA's should also be required by every department and trade involved in shipyard repair. Electricians, machinists, mechanics, and sandblasters/painters all deal with different hazards on a daily basis.

Safety committees are a great way to involve employees that are dedicated to safe work habits and the well being of themselves and coworkers. Safety committees in shipyards should be conducted by a group of skilled workers that work with management in a cooperative effort to promote safety and health at all times. Committees are encouraged to meet on a weekly basis during working hours to discuss any problems that have circulated in the facility. Safety committees are very important in shipyards and the whole maritime industry for increasing awareness and assisting management's role in safety.

Accident investigations should be conducted in shipyards anytime there is an accident and a worker is injured, equipment is damaged, or a near miss incident occurs. Accident investigations should be done in a timely matter in order to thoroughly get all the details. First you must determine the root cause of the incident and document what steps must be taken and corrective actions to prevent future situations. Interviewing each coworker involved and providing proper training will help eliminate future incidents.

Internal safety audits should be routinely conducted by supervision and documented to identify existing hazards, evaluate safety culture, and prevent future incidents. Audits need to

examine past workers compensation claims to identify which types of injuries are most common and corrective actions and training that have been put in place to mitigate future incidents. A common type of audit in shipyards would be a loss control/safety audit in which a third party auditor would perform a site visit to identify areas of concern or hazards that have not been previously addressed. Equipment, electrical, and general housekeeping will be inspected and workers can even be interviewed and questioned on safety briefings or concerns

. Proper Training

Proper training is an important aspect in the shipyard industry. A comprehensive training program is a key element of a shipyard's safety and health program. On the job and detailed safety orientation training is very effective for new employees because they are at a higher risk to be injured than seasoned employees. On the job training has also been proven to be more efficient than basic class room instruction and should be performed under the supervision of a qualified experienced trainer. Several trades require regular training updates, or annual refreshers in order to maintain skill levels and to stay current with any new operating procedures. Safety training should be conducted whenever it appears that an employee's behavior is deviating from safe work practices or when certain procedures should be changed to eliminate a hazard.

Companies are also reaching out to local high schools, along with vocational and technical schools to encourage the younger generation of students on the proper skills needed to work at their shipyards. Welding institutions are located all throughout the country and help certify welders with structural and pipe welding. Trade schools are working with local unions to

help students follow a career path as an electrician, machinist, welder, and even carpenter that all benefit shipyards. Along with these apprenticeship programs, maritime academies are assisting the future maritime workers with the skills and education needed for employment.

Shipyard companies are also providing counseling to motivate workers to change unhealthy behaviors and adhere to treatment recommendations. Employers are promoting health and well being with company provided gym memberships and Biggest Loser competitions directed from the television series. Wellness programs are also being developed as incentives for their employees to become healthy by giving them reductions in their healthcare costs for participation.

Personal Protective Equipment

Personal protective equipment is very important for employees in today's shipyards. Shipyards are responsible for providing their employees with the best available equipment and tools to conduct their jobs. It is the responsibility of each employee to properly wear and maintain their personal protective equipment. It is also a requirement that each worker inspects their PPE on a daily basis and replaces anything that is damaged. There are many different types of PPE used in shipyards but the most common include:

- Hard Hats are required in shipyards at all times except for office personnel and sometimes excluding diesel and machine shops. Hard hats are designed to protect from falling hazards and impacts from low overhead objects. They are even designed to

reduce electrical shock hazards when employees are working close to exposed electrical conductors. Hard hats have saved many lives and greatly reduce the chance of injury when struck in the head. Shipyards and towboats consist of many areas that include tight and low overhead areas. Tanks are especially crucial because of the piping and framing that run all along tanks. Hard hats are also color coded in shipyards to identify the class of worker in the facility. Foremen are required to wear white hard hats in order to identify themselves with customers and other supervision. Electricians typically wear green hard hats for classification. Many companies also require new employees to wear a yellow hard hat for identification and issuing red hard hats to workers with a year of seniority. These color codes help assist supervision in assigning work and specific duties.

- Steel toe boots are also required in all areas of a shipyard except inside office areas. Steel toe boots must come six inches above the ankle whether they are lace up or slip on. Lace-up boots are preferred because they give more ankle support although many welders and fitters prefer slip-ons during hot work. Steel toe rubber boots are furnished by the employer for any time there is tanking cleaning involved. Many shipyards also provide boot allowances for their workers to encourage proper care of their feet. Excessively worn out soles and heels on boots lead to many slips, trips, and falls in shipyards.
- Safety Glasses are required in all shipyard areas except break rooms and inside offices. Eye protection is very important because the eyes are very vulnerable to injuries in shipyards. Foreign bodies in the eyes account for over 25% of accidents in shipyards.

Shipyards are required to provide their workers with the first pair of safety glasses at the beginning of employment and old pairs must be turned in for a replacement pair. Side shields on prescription glasses are mandatory and also provided while contacts are not recommended while welding or in fuel tanks. Tinted glasses are not to be worn at night or in confined spaces and dark areas. All safety glasses must be stamped or exceed the test requirements of ANSI 787 or they will not be allowed. Safety glasses must be worn while under a face shield while grinding and welding hoods to protect from debris and even flash burn. Protecting your employees and taking the proper precautions will lead to reduced eye injuries in shipyards. Eye wash stations are placed in different locations to assist in minor incidents such as dust or dirt which occur from falling or blowing debris from winds. Protecting your eyes will always be preached and stressed in shipyards and should be an important factor for workers while at work and even at home.

- Hearing protection is required in all buildings of shipyard again excluding inside of offices, tool rooms, and break rooms. Hearing protection is required whenever a worker's noise exposure equals or exceeds and eight hour time weighted average (TWA) sound level of 85 decibels. While main engines and generators are running on towboats, the engine room easily reaches 110 decibels. Ear muffs provide the best amount of protection and are placed accordingly by each engine room door. Ear plugs are also available and help reduce noise by sealing the ear canal. Shipyards run their main air compressors at around 125 PSI and sometimes adjust the pressure depending on the various jobs and sandblasting going on. Hearing protection is mandatory when doing any hot work, pressure washing, air arcing, jack-hammering, and sand blasting. It is also

recommended while using grinders, chop saws, and while swinging sledge hammers that are common activities in shipyards. The constant tapping of a slag hammer from a welder in an adjacent space accounts for high noise levels. Over the years accidents and injuries have also resulted from hot slag entering a worker's ear while welding or cutting. Safety representatives have made ear plugs mandatory while performing any hot work in order to reduce the number of inner ear injuries. Ear plugs will not always protect you 100% from burns to the ear but will minimize the severity of the wound.

- Hand protection is vital in shipyards due to the constant working and forming of steel. Hand injuries happen frequently in shipyards due to not wearing gloves or the proper gloves made for that job task. Cuts and stitches account for the majority of hand injuries along with smashed-by and burns. Broken bones and even amputations are also other common hand injuries that occur in shipyards. Smashed-by accidents happen when workers hold an object with their hands while another coworker strikes it with a sledge hammer. These incidents are nerve racking because they could have been easily eliminated by taking a few extra steps and also by using the corrective tool. Burns normally happen from welders and fitters wearing the improper gloves during hot work. Gloves are to be replaced after wear and tear and inspected before each use for holes. Contact injuries from chemicals can be avoided while cleaning bilges by wearing chemical resistant heavy duty rubber gloves. Leather palms are to be worn while handling steel and wires and grinding operations. They are also mandatory during rigging procedures and during the use of chain blocks for lifting. Gloves don't always prevent hand injuries, but will always help reduce the seriousness of the incident. It is the

responsibility of each employee to take care of their hands and to know what type of gloves you need for the job task they are doing.

- Life Vests or Personal Flotation Devices are required at all times in shipyards when working off of work flats, boarding and unboarding of vessels, and working near unguarded edges where there is a possibility of falling into the water. Life vests are to be Coast Guard approved and worn properly. They must be buckled or zipped appropriately and inspected daily for wear and tears which may affect their strength and buoyancy. Type V flotation jackets are mainly used in shipyards as they are safe for use during hot work. Float coats are used in winter seasons and provide extra warmth in the cold weather. Deckhands are required to wear an LED C-light that manually activates a steady distress light when submerged in water.
- Respirators are provided by the employer and must be worn with many different circumstances. Respirators range from disposable dust masks to more complex supplied air respirators and employees must be clean shaved prior to orientation for a proper respirator fit test. Welders are required to wear respirators while welding with heavy metals such as brass and stainless steel. Sandblasters usually wear a supplied air blasting hood, while painters use a full face dual cartridge organic vapor respirator. Air quality tests are performed by the safety department to check for exposure limits and disciplinary actions are taken if workers are workers aren't wearing the proper PPE and respirators. Respirators protect your lungs from breathing in contaminants and along with proper ventilation will help you with the long term effects of exposure.

- Harnesses and lanyards are provided for fall protection and are stored in the tool room at shipyards. There should be enough harnesses and lanyards provided by the employer and workers should be trained and aware of their size and proper use. Harnesses should be inspected prior to use and also after completion for pulled stitches, cuts, and any frayed edges. The D-ring should pivot freely and the buckles should be checked for distortion. Lanyards should also be inspected the same way and retractable reels should offer proper smooth operation. Fall protection harnesses are used to protect a life in the event of a fall and should be treated with the same level of importance as the function they serve.
- Marine radios and alarms are the best means of communication in shipyard and marine facilities. Normally each tug operator and deckhands converse with one another on a certain fixed marine channel while the shipyard keeps its base station in the tool room for supervision to communicate. The tool room is required to stand by and alert supervision on upcoming weather alerts and soundings of general alarms. Man Overboard, Confined Space, and Fire are the three different general alarms that shipyard workers should be aware of. Training should be conducted periodically for employees and testing of equipment. New hires should immediately be trained on the different alarms and where to proceed in case of an emergency.
- There are many other different types of PPE used in shipyards that are not provided by the employer. Welders are required to wear long sleeves or other fire/flame retardant clothing such as leather jackets or aprons during hot work. Frayed clothes are not permitted and have resulted in many minor and major incidents where welders and fitters

have suffered 1st to 3rd degree burns from their clothes engulfing in fire. Rain and Tyvex suits are given to employees during any cleaning of bilges and fuel tanks.

Conclusion

The injury rate for workers in shipyards is nearly seven times the average rate for all workers in the United States (U. S. Bureau of Labor Statistics, 2017). It is hard work, many times in unfavorable conditions and known to be very dangerous. The good news is that it's getting better and the industry is catching up to the safety expectations seen in other industries. Shipyard work will always be a hazardous occupation, but many incidents can be reduced and mitigated with proper training and setting clear goals by management. An effective loss control program will help reduce injuries, prevent dangerous workplace activities, increase productivity, and also increase morale within the company. Shipyards are now surrounding themselves with professional safety and health engineers along with certified industrial hygienist to implement programs to fit the needs of their employees. They have learned that promoting safety as a priority will minimize incidents and increase revenue due to fewer workers' compensation claims.

Employees want to feel safe while they are working; many shipyard owners are now starting to protect their most valuable asset, their employees. Workplace safety is critical to protecting employees and is the cornerstone of success in the river and shipyard industry. It's no longer an industry that is ok as being seen as ten years behind in safety performance and things are changing for the better.

In the light of recent events in shipyards, safety is becoming a more prominent feature in the river industry. Customers are requiring that their vessels be repaired in facilities where safety standards are not only followed but expected in every facet of the job. It is up to management to create a culture where safety and production work as one to create the safest and most efficient shipyard possible. Loss Control should be a part of the daily operating plan of any shipyard as a means to protect the workers and create a safer workplace. Evaluating risks with proper training and developing a safety culture with a commitment from each individual will make for a better environment.

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