HANDI-STRAPS AND CS ERGONOMICS

While I have either entered or supervised entry in hundreds of confined and enclosed spaces in my 40 years of construction, my OSHA-recordable injuries occurring beyond the portal have been relatively few. However, an overwhelming number of confined space lost-worktime injures nationwide have been filed under musculoskeletal disorder (MDO) claims. Once we entered these enclosed and confined spaces, accidents did not seem to have root causes originating in catastrophic events, but rather repeated minor strains and short stresses accumulated while working long, hard hours in peculiar and unnatural postures. We had one cardiac infarction (at home, after work) on a demolition crew after a 12 hour shift in a confined space. The victim had undergone previous heart surgery but had never mentioned his compromised health status to his supervisor. I hadn't run many confined space operations before I realized ergonomic risks surmount almost all other hazards once my crew entered the space. Nobody told me the number one health problem by far would actually be caused by the worker not the atmosphere Nobody cared enough to take the time it took to train me in CS/MSD preventative measures. I have had to learn techniques over the years on my own from that familiar trial-and-error "school for fools".

While instructing confined space rescue (CSR) classes in recent years, it became evident that rescuers entering the portal of a confined space were at a *much* higher risk of MDO than the original entrants they were drilling to rescue. A CSR operation can sometimes resemble running a steeplechase blindfolded wearing a 100 lb rucksack. Once a CS Rescue team deploys on site, every member has one or more initial, pre-entry assignments to complete in a time manner under the auspices of an Incident Command System (ICS). While paired rescue-entrants are preparing to enter a vessel, the rest of the team is deployed to secure rescue limit lines, establish an Incident Command Center, set up communications, test atmospheres, initiate ventilation, rig rescue lines and

disperse equipment in a tactical laydown area. For the first few minutes "organized chaos" is going on everywhere. Members are scrambling through well-drilled activities often without an unnecessary word spoken. At times, under certain conditions, a hazmat support team may aid the rescue entrants in donning chemical protective clothing (CPC) and self-contained breathing apparatus (SCBA) in the Cold Zone prior to entry into a confined space Hot Zone while other members are setting up decon stations in the Warm Zone. All of these trained workers are moving heavy, clumsy loads quickly, often without concern for their backs, legs and arms. This is just the beginning of a strenuous series of events that will push the rescuers up to (but hopefully not beyond) their limits of physical endurance.

The term "failure" in structural analysis refers to the conditions of any component or system of components which shows visible, outward signs of wear, fatigue, or fracture, indicating it's ultimate strength has been or is about to be exceeded by means of load refusal, breakage or component separation. We all experience muscle twinges and spasms when we come near to muscle strain. Put into simple terms, the structure is no longer able to withstand the forces imposed on it by its own mass and any other external, environmental vectors. In many confined space cases, it is the "failure" mode of the entrant's musculoskeletal system which initiates the injury. In some cases this seemingly minor injury is just the *initiator* in a cascading chain of events which could possibly lead to a fatality if left unchecked during a rescue event.

We drill rescues for (3) primary reasons: 1) ***Test*** out our equipment for size, style and adequacy; 2) ***Evaluate*** our procedures for failure points and rescue-goal effectiveness; and 3) ***Practice*** our physical and mental capabilities to locate "soft spots". It is this last criteria which bears emphasizing. The old adage still holds*: None of us is always able to do everything, everywhere required of all of us*. It takes a team to achieve all the goals in a rescue plan. While the loss of one team member from a pulled hamstring, lumbar pain, or separated shoulder may be difficult to overcome, it should never be impossible to adjust the plan accordingly. Our rescue drills are always

"evolutionary" by design in order to create tangible obstructions, logical disruptions and foreseeable injuries.. No one is an expert. We're all just practitioners. We drill under escalating, worst-case conditions, until there is literally nothing we cannot overcome by working safely. We rescue like we drill and drill as if it is a rescue. Any tool, piece of equipment or procedure which aid in the timely completion of our assignments is called an "asset". Everything else is a "liability".

I have known Ron Kamerowski, the inventor of Handi-Straps ® (<www.handi-straps.com>), for more than a year. Handi-Straps ® is a lightweight, suspender-style set of lift-assist straps which enable the wearer to lift and pull weights much greater than normally possible, without the associated musculo-skeletal strains normally applied to the vertebral column and back muscles. I have a set of Handi-Straps myself and have spent hours evaluating them under various construction conditions and tasks, looking for deficits I could never find. It wasn't until recently it occurred to me to try using them in my Confined Space Simulation Trailer (CSST). The CSST is an 8 ft x 8 ft x 22 ft, 9,000 lb, trailer-mounted monstrosity, resembling a prop from a Mad Max movie. It is actually a sophisticated, mobile and adaptable training environment for confined space entry and rescue. Inside the unit dwells Rescue Randy, a 6 ft, 180 lb, articulated rescue manikin, resting peacefully on the tapered, inclined floor of the vessel. It is this "sim-vic" which plays such an important part in the "hands-on" portion of our CS rescue training. Accessing, assessing, packaging and transporting the victim to and through the egress portal defines the interior rescue-entry goals of the rescuers. From the moment the first rescue-entrant breaks the plane of the portal until the last rescuer egresses the space, the training event is primarily a musculo-skeletal torture test. Importing, carrying and setting up equipment in the confined space also occupies much of our time and energy during the 12 phases of a rescue. Extreme temperature conditions combined with a multitude of plan-shredding problems requiring solutions can seriously compound the physical and mental difficulties of a rescue drill. Let's evaluate a few of the physical events and conditions which can lead to MDO injuries during a CS rescue and analyze the effect that Handi-Straps might have on the outcome.

LOW CLEARANCES

This is almost always a given. Confined spaces, by definition, are capable of being entered and doing work inside, but not intended for continuous occupancy. This generally describes a structure or vessel in which an adult may not be able to stand upright or even be forced to knee or belly crawl some or all of the time. The great thing about the Handi-Straps is their compact size low profile. While donning and doffing Handi-Straps in some confined spaces may prove difficult, I usually put on my PPE (safety glasses, ear plugs, barrier cream, hard hat, gloves, knee pads, Handi-Straps before entering. I can stuff the arm straps into the pockets of my Carhartt jacket, between shirt buttons or tucked under chest strap to prevent them from snagging on obstacles. Like the lanyard attached to a harness, any dangling loop seems to entangle and hang-up on almost everything it comes in contact with. The Handi-Straps are also easy to donn over a full body harness as well. This configuration seems to work well as the straps do not seem to conflict with the function of the personal fall arrest system (PFAS). A full body harness is static until a fall occurs. The Handi-Straps are dynamic and used much more frequently. They should always be work outside your gear when feasible. When worn underneath a properly fit-tested full body harness the Handi-Straps felt restricted by the shoulder/chest straps and simply do not function as intended by the manufacturer.

When walking or standing under low clearances we assume positions ranging from a slight crouch all the way down to a "duckwalk". Unlike a Class III harness, the Handi-Straps have no leg straps or waist belt to fasten and so remain strictly managed by the chest and shoulder portions. Obviously, the more I can center my shoulders plumb over my pelvic girdle, the more dynamically effective the Handi-Straps become. The energy efficiency of transferring the forces of a load from the hands directly through the Handi-Straps to the shoulders helps to eliminate the creation of a moment arm on the spinal column. The "crane effect" of lifting improperly subjects the bottom 5

lumbar vertebrae and their intervertebral discs to a greater displacement force the rest of the column.. I carried one or two 35 lb buckets of wet sand in the simulation exercise. While using Handi-Straps even in a crouch (or stoop) I could still feel a tipping force acting on my whole body. Moving the "duckwalk position in a 45" diameter tube, I could only pull one bucket at a time behind me. In either configuration the stresses seemed considerably less (when resistance-pushing with the opposite strap) than when I assume the same loaded-crouch posture *without* wearing Handi-Straps. My product use analysis may be considered highly subjective and un-scientific, but at least it's real. Overall, I felt a distinct benefit to lifting in low clearances while wearing Handi-Straps. I would classify them as Assets.

AWKWARD POSTURES

Here is another practical "sure bet" in most confined spaces. At some time during the entry, the entrant(s) will be required to assume an unnatural body position for the purpose of either locomotion, hoisting, lowering or maintaining stability. There comes a time in almost every CS rescue where there are too many bodies (10 lbs) in a limited volume (5 lb bag). Sometimes this occurs during a crawl maneuver before you've even accessed the victim(s). Even following an adequate rescue plan, one rescuer may be required to pass another in a tunnel crawl or shaft rappel. I found that while the Handi-Straps provided no advantage to pulling *down* on a rescue pulley high-angle rig, if I anchored an additional transfer sheave at floor level, the Handi-Straps gave a distinct aid to the up-pull exercise. The Handi-Straps can be easily deployed when needed and stored outside of contact when not in use.

The most common structural defect of a confined space is a full or partial collapse. Fallen members and debris has no place to collect except in the volume you intend to occupy next. This may become either a minor annoyance or a severe disturbance requiring "Rescue Abort" command. Most of us inside will communicate our situation and set out to adjust, manipulate, redirect or simply

re-think the problems we face with the assets we have. I found that Handi-Straps were a great aid in lifting and moving simulated debris (sand buckets) in my confined space drill. Like a spelunker (cave climber/explorer) the use of body contortions provide a very real opportunity to fit ourselves into the pattern of obstruction until we can reach clearance on the other side. Unless I have a large object which needs to be grasped and moved to an out-of-the-way position, the Handi-Straps will not provide much aid in maneuverability. More importantly in a confined space, they will not restrict any body movement, limit the range of motion or entangle the limbs of the trained and experienced user. They may have only yield limited Assets in this category, but they contributed absolutely *no* Liability. That is a very crucial distinction

LIFTING HEAVY WEIGHTS

Here is where Handi-Straps excelled. Until you've had to grab and lift an unconscious, 200 lb person 10 - 12 inches and position him on a 30" wide board, leaning at a compound angle, you cannot imagine the difficulty it presents. Out in an level, open area (such as a firehouse truck bay) this can still be a spine-wrenching event. But in a confined space two rescuers maneuvering the dead-weight of an unconscious victim may prove especially stressful. With Handi-Straps, it just takes practice. It may be virtually impossible to lift the vic entirely off of the floor of the vessel to place him on a backboard. A partial spinal-roll or shoulder drag may prove to be the best methods to get him on-board. Two rescue-entrants, both wearing Handi-Straps, can clearly demonstrate the load-reducing factors of the device, during the victim package and transport phases. Depending on my posture during a contorted confined space lift, the Handi-Straps were variable in their load assit capabiliies, but their use seldom restricted or prohibited the lift. Any help in a CSR operation is always appreciated.

Keep in mind, with increased lifting capabilities, the most important issue to consider when ascending or descending a sloped surface is foot traction when moving and adhesion while standing.

The more weight you are capable of lifting is added your total body mass. Increased mass yields greater force on your working contact surface. Add a vector on an inclined surface and the more likely a slip, slide or shift will be. I have handled various weights in tandem and by myself in CS and as long as my spinal vector is close to plumb, the Handi-Straps were clearly Assets, with no foreseeable Liabilities.

PULLING AGAINST RESISTANCE

There is nothing more frustrating than knowing that you're capable of pulling an obstruction with mass free from it's , and yet, due to your position, you cannot apply an opposing force at either the required vector or with the necessary strength. The fact that you can pull far more with one hand in Handi-straps with the same energy usually requiring two . Within (3) basic size ranges, the straps are also individually adjustable in length to enable the user to shorten the strap thus decreasing the distance and increasing the pull force available. It's not a perfect science, but it does work. Position yourself sitting on your buttocks pulling the vic's upper torso toward you with a rescue strap between your knees. Grasp the rescue strap with one or both hands while using Handi-Straps and you will be capable of overcoming the bilateral force of resistance much more easily. A side-knee-arm crawl while towing the vic with the free hand is also enhanced while wearing Handi-Straps. As with a one-arm lift, extending the opposite hand in it's strap may resist the tipping-moment created by the lift. It is important to consider donning non-slip foot wear, gloves and rubber knee pads, as your pulling power will be increased, raising the potential for loss of traction at loaded contact points under feet, hands and knees. All of this took me some practice, but in the end, I estimate it improved by strength skill-set by 10-15% in some exercises and even more in others. That's a great advantage, when you consider the as-yet-undiscovered rescue obstacles you're assigned to overcome while running against the clock. Handi-Straps were clearly Assets in this category.

DISTRACTING EVENTS & DISRUPTIVE CONDITIONS

There are plenty of these to go around. Slip/trip conditions, loud noises, inclined surfaces, line entanglement, temperature extremes, loose material, falling objects, engulfment, entrapment, impaired visibility and communication black-out are just a few of what one trainee termed "snakes-in-the-grass". While Handi-Straps may not be considered Assets under *all* of these conditions, mitigating or abating *just a few* of the mentioned hazards will leave more of your mind and body available for emergency problem-solving. The conjunction of the mental status to the physical conditioning requires substantial focus for the rescuer during CS drills and rescue events. One attentive state usually effects the other, directly and instantly. Evolutionary rescue drills help rescue teams become familiar with the most distracting events and disruptive conditions, big and small. From sweat burn in your eyes to a paralytic "charleyhorse", these may prove to compound on themselves until goals fail and rescues abort.

Keep in mind, my brief experimentation with Handi-Straps in a confined space was merely a simulation. While all trainers strive to approximate the conditions of an actual emergency response, it is always an approximation, without the "intangibles" that come with a live emergency Unless and until I can use them in an actual emergency event, I cannot guarantee you that Handi-Straps deserve a compartment in your rescue rig. I can, however, assure you that *I will use them* in my CSR training as long as I still throw a shadow.

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