CH2M Hill Heat Stress Mitigation Efforts During Tank Farm Work Activities

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ABSTRACT

In the past, while working under the hot summer sun at the Hanford Tank Farms, workers were assigned a protective work-rest regimen and heat stress mitigation efforts were applied to prevent heat-related illnesses and minimize impacts to project schedules. In February 2006, CH2M HILL kicked off a heat stress improvement initiative led by an experienced person emphasizing the importance of worker involvement, employee education, and the application of the ALARA, or As Low As Reasonably Achievable, concepts of engineered controls, administrative controls, personal protective equipment, and physiological and work site monitoring. As a result of this initiative built upon previous years' efforts, CH2M HILL experienced increased "wrench time" during the summer of 2006 with fewer heat-related illnesses than in previous years.

ANALYSIS

For much of June, July, August and September, temperatures in the Columbia Basin can range from the high 80s to low 90s under clear skies. In late July through early August, daytime temperatures typically exceed 100 F. Add in low humidity, which rapidly strips away moisture, and the ever-present wind caused by being down-slope of the Cascade Mountains, working outside can swiftly change from being uncomfortable to hazardous to worker health.

In February 2006, CH2M HILL implemented an initiative to proactively address working in the summer months in a safe and productive manner. The mission statement for this initiative is:

> "To implement recommendations for heat stress mitigation during planning, scheduling and execution of work. This includes providing information to the work force, real time monitoring, and use of heat mitigation equipment and other infrastructure changes necessary to allow safe, productive tank farm work during the summer months."

Hot environments, high humidity and the physical demands of work can cause heat stress. This environment can be further complicated by protective clothing requirements used to perform radiological and chemical work. According to an article in *DOE Operating Experience Summary Report 2005-10 [1]*:

> "At 83 degrees with 60% humidity and impermeable protective clothing, a worker can experience sunstroke, heat cramps and heat exhaustion. . . Workers experiencing heat stress may have trouble concentrating and may become disoriented to the extent they can no longer tend to their own well-being."

To address the heat hazard, CH2M HILL developed an effective program to alert the work force to the hazard and then used Voluntary Protection Program (VPP), Integrated Safety Management System (ISMS) and Job Hazard Analysis (JHA) processes to identify the hazard and provide appropriate mitigation.

Worker training was developed and reinforced by weekly heat stress-related safety topics prior to the onset of summer heat. Company newsletter articles on new techniques for addressing heat stress were distributed to all employees. An emphasis on discussions of lessons learned in pre-job briefings was also established.

The reinforcement of good health practices was made to workers to include adequate hydration prior to, during and after work using water and/or electrolyte supplement while avoiding natural diuretics such as coffee, tea and colas.

Workers are encouraged to manage heat stress during the planning and execution of work using ALARA concepts of:

- Engineered Controls
- Administrative Controls
- Personal Protective Equipment
- Physiological and Work Site Monitoring.

This year's activities built on controls that were explored last year and on new equipment being tested within both the commercial nuclear industry and the DOE complex. Fundamental to this year's effort was getting employee buy-in on the concepts and equipment being used. Without employee buy-in, no matter what the data demonstrated, new concepts and equipment would not be accepted. This required listening to the needs of the work force and then finding the tools that addressed those needs.

Engineered Controls

Building on preliminary testing performed last year in CH2M HILL's Closure Operations organization, and on pilot programs at other DOE sites, CH2M HILL used several types of cooling equipment to manage the work environment with positive results. These included:

- Providing recirculating air conditioners in radiological containment tents. The roofs on the containment tents had the capability to open and close to support crane activities while still being cooled by the air conditioners. Wet Bulb Globe Temperature (WBGT) readings indicated that temperatures inside the containment were effectively reduced to the low 70s, up to 14 degrees lower than the outside temperature. Therefore, work was allowed inside the containment tent even with elevated outside WBGT readings. Without the air conditioning, the temperatures within the containment were significantly higher due to the radiant heat and lack of air flow within the tent. As a result, work had to be stopped when the WBGT limits were reached, usually in the late morning.

- Placing swamp coolers at radiological control points and PPE doffing and donning areas. These areas could also be used as cool down/rest areas when required by the work-rest regimen.

- Installing misters to provide general area cooling inside Radiological Buffer Areas in conjunction with shading from netting or pop-up shade covers. The mist was blown from the outside through the netting into work and rest areas. While some moisture accumulation was noted, no spread radiological contamination occurred.

- Providing shade coverings to support tank sampling activities. Due to the configuration of the equipment and work area, an air-conditioned containment tent was not an option. However, a netted shade area covering the worksite resulted in WBGT readings in the shade up to nine degrees cooler than the outside readings. The shade allowed work to continue into the early afternoon without applying a restrictive work-rest regimen.

Administrative Controls

Establishing administrative controls proved to be a significant improvement on supervisor and worker knowledge of the WBGT chart and how it applied to the work activity. In previous years, the chart was an "absolute" control that dictated how a job was managed. In some cases, the readings were taken well away from the work site and may not have been indicative of actual field conditions. With improved communications, employees understood that the chart was a recommended regimen based on a time-weighted average. The specified work-rest regiment was still routinely followed. However, through Industrial Hygiene (IH), manager, worker involvement and reliable job site readings, a documented approach to the work was established that allowed work to be performed in conditions outside the bands of the WBGT chart.

On some occasions, work was scheduled to be performed during the early morning hours when the WBGT readings were lower. However, these instances were less frequent than in previous years and were usually of very short duration.

All CH2M HILL employees were provided a laminated copy of the OSHA Quick Card on "how to protect yourself from Heat Stress." The State of Washington emphasizes use of the card due to positive experiences of emergency response personnel using the cards.

Personal Protective Equipment

The change implemented this year with the biggest impact on worker comfort was the widespread use of lighter radiant cooling vests and more breathable anti-contamination clothing. Worker acceptance was the foundation of the successful use of this new PPE.

During the summer, CH2M HILL piloted the use of OREX PVA coveralls during several work activities. While the coverall's primary function is to provide a disposable anti-contamination clothing barrier, it is also designed to be a PPE mitigator for heat stress. The OREX PVA PPE is 70% lighter and 20% more breathable then current cloth coveralls. The results of the pilot tests

were in line with expectations based on 100% crew satisfaction, no skin or clothing contaminations, and manageable usage issues. Below are the results of the pilot:

- The original order specified the baseline Model 1302 overalls. During the first two zone entries for the sampling crew, three PPE failures were noted. The mode of failure was that the wearers tore out the crotch seams while climbing up on the sampling truck. An additional failure occurred when an HPT tore the crotch seam while using steps in the SY Tank Farm. No skin or personnel clothing contaminations occurred as a result of the PPE failures. Initially, the crews were instructed to tape the bottom legs of the PPE to the booties such that the pant legs were loose and to use one size larger than usual to allow for more leg room. As a follow up, the distributor was contacted. This issue had been identified by other facilities with the immediate fix to put people in an upgraded model number (1304), which contains a double-stitched crotch seam. According to the vendor, the next run of the basic model will also have the double seam. No other failures have occurred since these actions were taken. The 1304 model is being tested in the field.

- The OREX anti-c's are not for every application and need to be evaluated for use when the job is planned. The pilot-controlled application issues now need to be addressed in the planning meetings for the specific work and in CH2M HILL source documents. The Radiological Work Permits for non-pilot activities specify the OREX coveralls. Controls include:

    - Do not wear the 1302 and 1304 models in an environment where they are can become wet. Moisture can result in wicking of contamination through the garment.
    - Do not wear any of the OREX PVA coveralls in an environment where fire retardant or arc flash protection is required.
    - Cut the lower elastic band on the bottom of the leg during the donning process to facilitate removal of the coveralls (CH2M HILL is working with the vendor to facilitate removal of the elastic in a larger procurement).
    - Because the PVA coveralls are disposable, marking with the radiological controls tri-foil is not required.
    - When taping the lower leg seam to the bootie, do not tape the leg down tight.
    - When wearing the 1304 model, tape the zipper cover down.
    - The booties run very small and are hard to put on and take off over the safety shoes. The pilot allowed the use of standard booties with the PVA coveralls (CH2M HILL is working with the vendor to increase the size of the bootie to facilitate wearing with safety shoes).
    - The hoods have not been used as much as the PVA Coveralls since they are not required for all work activities. The PVA hoods use a two button system for closure instead of Velcro. This has not caused a problem. The hoods were also accepted by workers as they were much cooler than standard hoods.
    - The PVA coveralls do not have pockets to hold personal monitoring air pumps. When wearing two sets of coveralls with the air pump on a belt on the inner set, the pump wore holes in the outer set. To address this issue, the vendor provided a work pouch to wear over the inner set of coveralls which allowed the pump to be

worn in a "pocket" to prevent rubbing on the outer set of coveralls. This is currently being evaluated.
    - Inexpensive disposable knee pads were procured to provide an additional level of protection should a worker's knees inadvertently touch the ground.

- The waterproof model must be procured for use in environments with the potential of contacting liquids. This level of clothing is coated with a wax to repel liquid. Demonstrations by the vendor indicated that the PPE was effective in preventing water transfer through the cloth. This provided protection from liquids while still providing heat stress relief. In one application, standard PVA coveralls were worn as the inner set, and a set of waterproof PVA coveralls were worn as the outer set, which resulted in the elimination of one set of impermeable rain gear. It was also much cooler for the workers and allowed the work to be performed without physiological monitoring. Vendor information states that the waterproof PVA coveralls are still 90% as breathable as their standard set. The workers agreed that they were much more comfortable and less stressed with this PPE change.

Radiant cooling vests manufactured by Arctic Heat USA were also tested and provided to the work force. The vests are much lighter than previous models of cooling vests and can be worn with bottle-supplied breathing air. The vests contain a non-toxic, biodegradable, viscose gel that absorbs water. The materials used in the vests are designed to lower skin temperature, which in turn stabilizes the core body temperature. This allows a person to stay cool and sustain peak performance levels much longer during work activities. Workers were able to wear a frozen vest in the morning, put it back in the freezer during lunch, and then wear the same vest again in the afternoon.

All wearers reported more comfortable work activities in the heat of the day. In some instances, the arctic vests were worn under PPE with very positive results, including no sweating through of the vest to the coveralls. More work will be necessary next year to develop protocols for wearing the vests with PPE. The vests were provided as personal equipment to those who requested them.

Physiological Monitoring

Physiological monitoring is the ribbon that ties a bow around all of the other tools in the heat stress tool bag. By monitoring each individual, field work supervisors and IH Technicians can determine the effectiveness of the mitigation being employed and assign appropriate rest periods to protect the work force. Physiological monitoring is also required when workers are wearing impermeable PPE and the WBGT is greater than 75 degrees. IH Program personnel are developing a management directive to perform a pilot of "pulse rate" monitoring by checking the pulse on the finger. This can be used in a contamination area by an IH technician supporting a crew and provide individual monitoring instead of the "crew approach" to the conservative WBGT. During the winter months, CH2M HILL will evaluate other pulse rate monitoring devices that allow for remote monitoring to supplement the finger pulse rate checks.

SUMMARY

The success of the Heat Stress Mitigation Program can be attributed to addressing the hazard in ISM and VPP terms and then applying ALARA principles to the hazard. Indoctrination of the work force is fundamental. Without knowledge of the hazards and their mitigation, employees can not be expected to plan, supervise, and work in a heat stress environment.

The planning activity must identify when heat stress environments are present, which may be either seasonal or result of from use of PPE in a heated work space. In either case, the planning activity needs to evaluate the type and level of mitigation. The mitigation may be engineered controls, administrative control, PPE, physiological monitoring or a combination, but needs to be determined in advance and then factored into crew briefs and training.

Because of this year's efforts, CH2M HILL is in a much better position to perform work safely in a heat stress environment.

REFERENCES

1. *DOE, Operating Experience Summary Report 2005-10*, U.S. Department of Energy, Office of River Potection, Richland, Washington (2005).