HNF-21886
Revision 0

Prevention of Heat Stress During Radiological Work

Prepared for the U.S. Department of Energy
Assistant Secretary for Environmental Management
Project Hanford Management Contractor for the
U.S. Department of Energy under Contract DE-AC06-96RL13200

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Richland, Washington

Approved for Public Release;
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PREVENTION OF HEAT STRESS DURING RADIOLOGICAL WORK

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PREVENTION OF HEAT STRESS DURING RADIOLOGICAL WORK

Background

Hot environments, high humidity, and the physical demands of work cause heat stress. It is further complicated by protective clothing requirements commonly used to perform radiological work. The resulting physiological strain is reflected in increased sweating, heart rate and body temperature. Uncontrolled exposures to heat stress can lead to decreased performance, accidents, nausea, weakness, and heat disorders.

Environmental sources of heat stress include convection, which is heat transported by air movement; radiant heat, which depends on the temperatures of surrounding walls, equipment and other surfaces; and air humidity, which affects the body's ability to cool by sweat evaporation.

Protective clothing worn during radiological work may affect the body's ability to cool by sweat evaporation. Multiple layers of clothing, especially impermeable plastic clothing, significantly reduce the body's ability to evaporate sweat and thereby cause greater physiological strain.

This handout provides guidance on actions that can be taken to reduce the possibility of incurring heat-stress-related injuries during radiological work.

Requirements

This Handout supplements HNF-PRO-121, *Heat Stress Control.* Section 4 of HNF-PRO-121 lists the mandatory requirements for working in conditions with the potential for heat stress. These requirements include, in part the following actions:

a. Before work is performed, the potential for heat stress must be evaluated. The evaluation will be part of the Job Hazard Analysis (JHA) and the Automated Job Hazard Analysis (AJHA) or a similar tool.

b. If the JHA indicates the potential for heat stress, the requirements of the most recent edition of the American Conference of Governmental Industrial Hygienists Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices must be followed.

c. The project/facility Occupational Safety & Health professional must be involved in the evaluation of the heat-stress level and implementation of heat-strain controls if the JHA indicates a potential for heat stress.

d. Line management shall ensure that each employee who is potentially exposed to heat stress is provided with documented training appropriate for the use or situations/locations where the exposure(s) could occur. This training will include (1) medical conditions resulting from heat strain, (2) possible sources of exposure during the job and from the environment, (3) actions to minimize the potential for heat strain, (4) engineering/administrative controls for heat stress, and (5) emergency procedures for heat-related illnesses.

   NOTE: There is a Hanford training course (Heat Stress Training - 020193) in HGET related to heat stress that includes signs, symptoms, measurements, and control measures. This course is not mandatory, but does meet the training requirements listed above.

Table 1: Five Common Types of Heat Stress Disorders

TITLE	CAUSE	TREATMENT
Heat Rash	Caused by obstruction of the sweat glands brought on by chronically wet skin. Symptoms are itchy skin with small red spots and an unusual sensitivity to radiant heat.	Allow intermittent relief from the hot environment. Heat rash can be prevented by keeping the skin clean, and periodically allowing the skin to dry.
Heat Cramps	Caused by profuse sweating and hard work, which results in an excessive loss of salts. This results in painful muscle cramps in legs, arms or abdomen. The cramps may occur during or after exertion.	Massage cramping muscles to obtain relief and give water orally. Prevent heat cramps by adding extra salt* to food.
Heat Syncope (sin-ka-pee)	Occurs when a worker maintains one work posture (e.g., standing or squatting) for too long a time. This allows blood to pool in the legs, away from the head. Standing or sitting up quickly will cause dizziness feeling ("grey out") or a brief fainting spell (black out), of less than 30 seconds.	Allow the worker to rest lying down. Administer water or other suitable fluids orally. To prevent or reduce heat syncope, instruct workers to flex their leg muscles several times before moving from a stationary position, and to stand or sit up slowly.
Heat Exhaustion	Often precipitated by heavy sweating, which causes dehydration. If a person is already dehydrated due to an illness (vomiting or diarrhea), the onset of heat exhaustion will be hastened. The symptoms are a general feeling of fatigue or weakness, uncoordinated actions, headache, thirst, and weak pulse.	Simply rest in a cool environment. Prevent heat exhaustion by drinking water or other suitable fluids frequently, and by adding salt* to food.
Heat Stroke	This is a life-threatening condition. It may be brought on by a pre-existing illness (e.g., fever or flu), an abnormal intolerance to heat stress, excessive exposure to heat stress, or by drug or alcohol abuse. A person in heat stress will have difficulty recognizing surroundings or people and may exhibit irrational or unexpected behavior. The skin will be dry and convulsions or unconsciousness for periods greater than 30 seconds may also occur.	Immediately and aggressively lower the person's body temperature. This can be accomplished by wetting the skin and clothing and increasing the airflow by using fans, ventilation trunks, or hand fans. Ice packs may also be used if available. Transport the person immediately to an emergency medical facility. Prevent heat stroke by training personnel to recognize the symptoms of heat related disorders by allowing the workers to participate in the determination of heat stress exposures. Workers who maintain a healthy life-style will be less likely to have heat stroke.

***NOTE:** Lightly salting food at mealtimes is encouraged both as a treatment for, and prevention of, some heat disorders. Those individuals on salt-restricted diets should consult their personal physicians regarding the advisability of exposing themselves to heat stress and the supplementing of salt intake. Salt tablets, however, should never be used. In addition to causing stomach irritation, salt tablets retard the absorption of water into the body where it is needed to support adequate blood flow and sweating.

Managing Radiological Work

In order to accomplish radiological work in hot environments, it is necessary to manage the work, recognize the potential for heat stress, and take measures to prevent it. Effective management requires that an evaluation be performed to assess the potential for heat-stress situations and then to use control measures to mitigate the stress. Most facilities have an Industrial Safety/Industrial Hygiene (IS/IH) person that can help with this evaluation. Contact the IS/IH technician **prior to the start of the job** to evaluate the temperature/humidity, the work package, environmental heat sources, work demands, and clothing requirements. This evaluation may include a job walkdown and participation in mockup training.

Planning personnel, Field Work Supervisors, and the Person-in-Charge (PIC) should review local Safety Standards and Guides when preparing for work that has a high potential for heat stress.

If the job site is in a remote location, line management should contact emergency personnel prior to the start of the job to inform them of the location and the possible need for assistance should a heat stress incident or other medical emergency occur.

Work Demands

Work demands are divided into three categories. Light work includes activities such as instrument repair, supervision, and valve lineups. Moderate work is typical of most maintenance tasks, and heavy work requires a great deal of physical effort (e.g., continuous shoveling, mopping, installing shielding).

Worker Training

Training the workers is essential in preventing heat-stress related injuries. Training provides individuals with the knowledge required to deal rationally with heat-stress and encourages them to make a commitment to follow good health practices. This training is usually repeated periodically and covers subjects such as the sources of heat stress, physiological responses, heat stress hygiene practices, acclimation, recognition, prevention and first aid for heat disorders. The pre-job briefing conducted just before the work starts should include these same key points and a reminder to personnel that if they feel they have the symptoms of heat stress to notify personnel and exit the work area.

Good Health Practices

The primary method of preventing heat stress is to follow good health practices. This is solely in the hands of exposed workers. Site management has a responsibility to minimize the barriers so that good heat-stress practices can be followed, but it is ultimately an **individual responsibility**. Good health practices for workers who will be exposed to a heat stress environment include the following:

- Fluid Intake is needed to replace water lost by sweating. Ideally, water is replaced on a frequent schedule (e.g., 8 ounces [1 cup] 3-4 times per hour). On some radiological jobs, there may be restrictions on drinking to avoid ingestion of radioactive or chemical contaminants. Workers should be encouraged to prehydrate (drink more than usual before the heat exposure), and then drink additional water afterwards. An ample supply of liquids such as cold water, fruit juice, or Gatorade should be available for the workers. The use of caffeinated beverages such as coffee, tea, and colas, should be discouraged since these products are natural diuretics that cause increased urine output. (See Appendix A)

- Balanced Diet: Workers should be encouraged to eat a "light" meal before entry to control nauseous feelings. In addition, eating a "light" meal will reduce the amount of blood required for digestion and allow more blood to flow to the surface of the skin for cooling.

- Self-Monitoring is both a health practice and an administrative control. The individual worker must understand there are differences among workers for heat tolerance, and each individual should stop work and exit the work area at the first symptoms of fatigue, nausea, or other signs of heat disorders.

- Life Style relates to the worker's personal activity off the job, such as alcohol and drug abuse, and heat exposures outside of the work environment. These activities can greatly affect each worker's ability to perform work in a heat-stress environment.

- Health Status is the recognition that chronic or acute illness can increase the risk of a heat disorder. Personnel who are sick should not work in a heat-stress environment.

- Acclimation is frequently considered an administrative control. It recognizes that performance under heat-stress conditions improves with successive exposures and that expectations should be adjusted accordingly. For example: ten successive days of heat exposures lasting at least two hours are required to obtain the most benefits of acclimation. As a rule of thumb, one day of acclimation is lost for every two days that a person is not exposed to heat stress. (The ratio is one-to-one if the absence is due to illness.)

After the job is evaluated by planning personnel and the Industrial Safety/Hygienist, specific actions can be identified that will reduce the probability that heat stress will occur. Priorities should be given to controlling the greatest contributors to heat stress through the use of engineering controls, and then, administrative controls and personal protective equipment (PPE).

Engineering Controls

Permanent and temporary engineering controls are the first consideration. Any mechanical assistance that can reduce work demands will cause a significant reduction in the level of heat stress. For instance, the use of electric-, hydraulic-, or pneumatic-powered tools to remove/replace fasteners reduces the physical work of the user.

Determine if there are ways to modify the worker's environment. If existing ventilation systems are broken, determine if they can be fixed. Can the area be shaded or insulated? Can work steps be moved to a cooler environment? Can workers use different work practices?

Dilution ventilation and air conditioning can cool the work environment inside a facility or containment. HNF-PRO-121 states that "When temperatures are at or in excess of 95 degrees F, forced-air ventilation should not be used unless it is cooled." Ventilation systems can be used to remove smoke and heat from the work area or confined spaces. Air conditioning a containment tent is possible but requires a large air conditioning (A/C) unit to make up for losses through the non-insulated fabric. Normally, the most efficient ventilation system takes most of the air discharged from the HEPA ventilation blower and routes it back to the air conditioner where it is drawn into the A/C unit and discharged into the containment. This recirculates air that has been cooled rather than continuously drawing in hotter, ambient air.

Where radiant heat is a factor, shielding, insulation, and decreasing surface radiated heat are possible solutions. The more reflective (shinier) a surface, the lower its ability to radiate heat to a person. Sometimes work-area temperatures can be reduced by covering the work area with white or reflective materials so that it is shaded and sunlight is reflected. If the work is inside a tank or building, a garden hose/sprinkler can be placed on top of the area to cool down the structure and reduce the radiated heat. Water should not be allowed to drain into the work area. Closed-circuit TV cameras can be mounted so that personnel outside the work area can observe the workers and look for signs of heat stress. Inexpensive communication systems are available that can be worn under protective clothing and not interfere with the wearing of a respirator. If such communications equipment is used, the workers and personnel at the work-area boundary could communicate with each other frequently to detect early signs of heat stress.

Workers have successfully used harnesses made from *Tygon® tubing with holes drilled at several locations. The tubing is worn under protective clothing and connected to an air line. Air pressure in the tubing exhausts around the worker's body. These tubes can be made for less than $3.00 each. Other vests have similar tubing with holes that release the air around the worker's trunk area. Some of these units can be connected to a Powered Air Purifying Respirator to eliminate the need for an air hose.

Another type of circulating air system consists of a compressor capable of supplying large amounts of air at the proper purity for breathing, with or without a vortex cooling device supplied to personnel wearing an air-fed or "bubble" hood. Again, the NIOSH requirement is that the flow rate to the hood be 6-15 CFM. Experience shows that adjusting the air to the air-fed hood at about 11 CFM seems to satisfy most workers. Higher flow rates create more "noise" inside the hood. A vortex cooler can cool the hood air by 50 degrees F for up to four personnel. Other companies sell small vortex cooling devices that are attached to the worker's belt. These units are advertised to cool the air in the hose by 30 degrees F. If workers are wearing impermeable plastic clothing, the air enters the clothing from the air-fed hood and exhausts around the ankles or through special vents installed in the leg/arm of the plastic clothing.

When all the planning for a job is complete and workers are still required to wear full-face respirators or extra sets of protective clothing, go back and rethink the engineered controls. Remember the following consequences, if the job requires respiratory protection:

- There is a 20-25% loss of efficiency when a worker wears a respirator. This applies to most activities and results in a 40% reduction when the respirator is worn in addition to waterproof outer garments. This additional protective equipment affects personnel in two ways:

  (1) Alteration of the physical relationship between the workers and their environment - workers move differently, almost like robots, when wearing respirators.

  (2) Deterioration of the physiological condition of the workers - the consequences from conditions that affect the worker's health may be more adverse than exposure to the radiological conditions.

- Several factors cause increased stress on respirator users:

  a. Increased breathing resistance.

  b. Increased dead air space (worker has to breathe in more oxygen-rich air to replace oxygen-deficient air trapped in mask).

c. Additional weight.

d. Ergonomic concerns (worker enlarges, balance is effected and simple tasks are more difficult).

e. Restricted vision.

f. Restricted communications.

g. Psychological distress (anxiety level increases).

h. Physical discomfort.

- Each prescription for adding respiratory protection or additional layers of protective clothing should be written only after a thorough assessment of the work area, evaluation of available engineered controls and an understanding of what actual work is required.

Administrative Controls

If engineering controls only lessen the heat-stress (not eliminate it) or if they are not practical, then administrative controls can be used to reduce the risk of an overexposure to heat stress. Some of these controls include the following:

Emphasize self-determination, which is an acknowledgement that workers may and must terminate a heat-stress exposure at the onset of symptoms of a heat-related disorder. This is one of the most important factors in managing heat stress.

An environmental "stay time" and/or work/rest regimen can be established for various work steps by reviewing applicable Safety Standards and consulting with the facility is IS/IH. The stay time is the maximum time a person may be in the heat-stress situation. Personnel should be ordered out of the work area in advance so they can be out of their protective clothing when the stay time expires. They should then be required to rest in a cool location for a minimum time determined by the IH. In addition, at periodic intervals, the PIC and/or other personnel running the job should question each person in the work area to determine (1) if they are experiencing any symptoms of heat disorders, and (2) if they can continue to work. Each person should be asked the questions and a decision made on whether or not to continue, based on the response of each individual.

Recovery allowance and work/rest cycles are designed to allow sufficient recovery from previous heat-stress exposures before a subsequent exposure is undertaken. The work/rest regimen observed should be established by the facility IS/IH per instructions of the American Conference of Governmental Industrial Hygienists and modified to reflect worker acclimatization, work type, and clothing type for "physically fit" workers. The "rest" area selected should be shaded, cooled, and preferably indoors. If temperatures are high, a Wet Bulb Globe Thermometer (WBGT) can be installed in the work area by the Industrial Hygienist.

Scheduling hot work to a time of lower heat stress is a commonly recognized control method. Working hot jobs on back shifts when air temperatures are cooler, or scheduling the work to be accomplished in late Fall through early Spring are examples of this strategy.

Clothing requirements should be reviewed and possibly reduced to lower the potential for heat stress by Radiological Control. This may require that areas be decontaminated or covered to reduce the possibility of skin/clothing contamination to justify the reduction of PPE. The modesty clothing worn under the protective clothing could be specified to be shorts/tee shirt instead of the standard coveralls worn at many facilities. With the concurrence of the Radiological Control Manager, and at the worker's option, the tee shirt and/or inner hood could be "wetted" before dressing in protective clothing.

During work, personnel in the work area should use the "buddy" system to observe each other for signs of heat stress. The Person-in-Charge/Field Work Supervisor should control the work rate by allowing the workers to set their own pace.

With the assistance of the IH, commercial equipment can be obtained to monitor body temperature and heart rate. Trained personnel must be on hand to evaluate the readings and determine required actions.

If there is a high potential for heat stress on a particular job and personnel can be continuously observed, consideration should be given to establishing a "Hero" watch at the work-area entrance. The Hero watch would be dressed in protective clothing and have the proper dosimetry so he/she could immediately enter the work area to assist personnel if they show signs of heat stress. If direct line-of-sight of the workers is not possible, consider using cameras and communication systems to maintain continuous contact.

Personal Protection

Personal protection in the form of personal cooling and reflective clothing is recommended when the environmental stay time is very short. The Website http://koolnsafe.com/~jkool/cgi-bin/cart.cgi shows examples of the personal cooling devices that are available. This site may or may not be the best place to purchase this technology, but it does provide one location where all the popular technology is shown.

Personal cooling can consist of circulating air or water systems or ice garments. MSA and 3-M manufacture breathing air hoods that connect to a PAPR. The flow rate of air into the hood is a minimum of 6 CFM. Typically, workers breathe 2-3 cubic feet of air per minute. The extra air that isn't breathed is what cools the worker's body. Since the inner bib of the hood is tucked inside the protective coveralls, the airflow is into the hood, over the person's face, down through the coveralls and out through vents or the weave of the protective clothing. The National Institute of Occupational Safety and Health (NIOSH) requirement for wearing a hood is that the system supply air to the hood at a rate of 6-15 CFM.

"Ice vests" are vests containing Blue-Ice or other chemical gel packets in several pockets. The blue-ice is frozen to 32 degrees F and the other chemical packets are about 65 degree F. The vests weigh about 12 pounds and allow a great deal of worker mobility with typical service times of 1-2 hours. Ice vests do not work well for longer jobs unless the ice packets can be changed out after they reach room temperature. Some workers think the blue ice is too cold at the start and thaws too quickly. In addition, most workers don't like the extra weight of the vest, especially when the vest is no longer cold.

Other cooling devices that have proven effective include systems that circulate ice water through tubing woven into pants, shirts, and vests. Power to move the water is supplied by a pump and water bottle worn by the worker. An Innovative Technology report, written by Fernald, shows that if 9 hours of work can be accomplished during periods when the temperature is greater than 85 degrees, the cost of the equipment will be recovered. Workers at T-Plant used this system inside a containment tent but instead of wearing a pump on their back, the ice water was continuously circulated through a hose connected to large ice chests outside the containment. Savannah River Site has higher temperatures and humidity than Hanford and workers at this site wear a vest that has a bladder located inside the vest. The bladder is charged with cold water. When the cold water in the bladder becomes warm (~ 1 hour), the worker can recharge the bladder with cold water.

If air-supplied respirators or air-fed hoods are worn, the hose length should be minimized and the hose should not be laid against hot surfaces. Consider covering the hose with foam pipe insulation and wrapping the outside with white or reflective material. If portable air bottles are used for the breathing air, the bottles could be wrapped in white or reflective material, placed in the shade, and sprayed with water.

With the permission of Radiological Control, personnel who are monitored on a bioassay program and not wearing respirators may be able to drink liquids while in the radiological work area. Follow the instructions of the Radiological Control Technician (RCT). As a minimum these instructions should include the following: (1) step to a location at the work area boundary designated by the RCT, (2) stop all other work producing airborne contamination, (3) survey the worker's hands and face, changing gloves as necessary, (4) use a closed container approved by the RCT to dispense fluids, and (5) survey any equipment passing over the work area boundary at the completion of drinking. Dispose of drinking cups/utensils after each use. Refilling is normally allowed, but the cup/utensils cannot be left unattended and reused.

Lessons Learned

Hanford workers have had success in accomplishing work in hot environments using the following:

a. Solar barriers made from white or silver Herculite were erected to shade containments. The barrier above the tent reflects the sunlight and creates an air space between the tent and the barrier. Camouflage nets were also used to provide shade.

b. Containments installed around pits had inner and outer containment walls. Misters blew cold damp air into the space between the tent walls. This made the inner tent much cooler and reduced the wet-bulb temperature inside the tent. Misters can be used to cool off workers as long as they stay back far enough so their protective clothing doesn't get damp.

c. Cool air was supplied to vests worn under the protective clothing.

d. Preparation of concrete surfaces was done with shrouded tooling or underwater to reduce potential for spreading contamination, which would have increased the need for more protective clothing.

e. Air conditioning in the tent provided a cool area where workers could go and cool off.

f. Breathable Frham-Tex II protective clothing was worn to eliminate the need for impermeable clothing worn over cotton-blend PPE.

g. Pre-job briefings were held the day before the job to get the job started earlier in the morning when temperatures are cooler.

h. A "Cool-Down" trailer was set up to provide a standby area where workers can congregate and keep cool during job stoppages.

Definitions of Terms

ACGIH: American Conference of Governmental Industrial Hygienists - An organization of professionals in governmental agencies or educational institutions engaged in occupational safety and health programs. ACGIH develops and publishes recommended occupational exposure limits for chemical substances and physical agents.

REST: A total cessation of work in a shaded environment to allow for cool-down between work periods. Personal protective equipment (PPE) should be removed as required during rest periods.

TLV: Threshold Limit Value - Term used to describe exposure levels that all workers can be exposed day-after-day without adverse effects.

WBGT: Wet Bulb Globe Temperature - usually determined by Industrial Hygienists using an instrument that compares dry bulb, wet bulb and globe temperature.

References

1. Bernard, T. "Features of Heat Stress Control", 1989; Radiation Protection Management, Vol 6, No 4

2. Carls, D. "Heat Stress Control", Waste Tank Safety Support, Westinghouse-Hanford Company

Products

1. Automatic Vortex Breathing Air Cooler, Innovative Systems, Bremerton, WA 206/698-9418

2. Personal Vortex Cooling Device and Air-Fed Hoods, Lanc's Industries, Kirkland, WA 206/823-6634

3. Air-Fed Hoods, Nuclear Power Outfitters, Crystal Lake, IL 815/455-3777

Notes

*Tygon is a registered trademark of Norton Company

Appendix A

HYDRATION GUIDELINES

Keep Your Body Going with Fluids

The human body needs fluids to prevent overheating, especially when workers are physically active. More fluids are needed when working during hot summer days. Not all fluids are created equal. Just because something satisfies your thirst doesn't mean it keeps you hydrated enough.

An ideal beverage for active people has the right balance of water and electrolytes, minerals useful in sending electrical impulses through the body. The most important minerals for hydration are sodium, potassium, and magnesium. These minerals are lost when people sweat and urinate, so it's essential to replace them.

Below is a list of beverages with their hydration ratings. <u>Five is best on a hydration scale of 0-5.</u>

FLUID	HYDRATION RATING	REMARKS
Water	4	Water is adequate but not optimal, unless the person eats snacks to get carbohydrates and sodium. Water is okay for active people as long as the activity lasts no more than 30-45 minutes. Water is best for thirsty inactive people.
Juice	3.5	Okay after activity because of its nutritional value, but doesn't have the right mix of sodium, carbohydrates, and water for replacing liquids. The sweetness may keep people from drinking enough. For some, juice may contain too much sugar, which may affect performance
Soda	1	Sugar content in regular soda does not promote quick absorption into the body. Diet soda isn't much different than water. It doesn't add any carbohydrates for fuel, but has fluid. The carbonation may bother some people, and the sweetness may keep people from drinking enough.
Iced Tea	2	It can be a diuretic, encouraging urination and causing the body to lose fluids. The caffeine in most iced teas can help performance. Experts disagree on whether or not the amount of caffeine in teas and sodas is enough to increase urination.
Sports Drink	5	Most good sports drinks are better during and before activity, not after. Read labels carefully because some products are better than others. Look for about 6% carbohydrates (about 14 grams) for every eight ounces of fluid.
Energy Drink	0	Not helpful for hydration. There is not enough information about the possible risks from the ingredients. Energy drink refers to a flavored beverage that contains stimulants such as taurine, guarana, and caffeine.

Don't Wait to Hydrate

- Never let thirst be your guide. By the time you're thirsty, you're already dehydrated. So drink before you're thirsty.

- If inactive, check the color of your urine to see if you need to drink more fluids. If the color is closer to dark yellow, drink more water.

- If you're active, weigh yourself before and shortly after work or exercise to find out how much fluid you need to replenish immediately afterward. The difference between the two numbers is the amount of fluid lost. For example: A person that loses 2 pounds after work or exercise needs to drink the fluid equivalent to bring their weight back to the pre-activity level and add more fluid. This fluid should be drunk within two hours.

- Take hydration breaks when you're active and drink some liquid every 10-15 minutes, if possible.
- Drink about 500 milliliters, or 16 ounces of fluid two hours before activity.

- Keep the fluids cool enough so the person enjoys drinking them.

- Eat fruits rich in fluid, such as cantaloupe, watermelon, and grapes.

- Expect to drink more fluids than usual when it's hot because your body is working harder to regulate your temperature.

NOTE: Appendix A was taken, in part, from an article in the *Tri-City Herald*, of July 8, 2004. The article was written by L.Liddane (lliddaneocregister.com) and the chart was prepared by L. Kenny and D. Casa, spokesmen on hydration for the American College of Sports Medicine, and R. Kersey, professor of kinesiology and health science at California State University at Fullerton.