ERGONOMIC RISK IDENTIFICATION

A. OVERVIEW
   1. The following risk factors are associated with injury and disease resulting from poor job design (Joseph & Long, 1991; Schierhout et al, 1993; St Johns et al, 1993; Orgel et al, 1992; Stock, 1991; Keyersling et al, 1992; Hagberg, 1992): extended reach forceful exertions mechanical stress repeated exertions (repetitiveness) stationary standing (prolonged) stressful (unusual/abnormal) postures temperature extremes twisting (lateral bending) vibration
   2. Cumulative trauma disorders (CTDs) (also called "Repetitive Stress" or "Repetitive Strain") have been identified by particular disorders which represent specific jobs (Konz, 1990): bricklayer's shoulder cotton twister's hand gamekeeper's/skier's thumb stitcher's wrist telegraphist's cramp
      a. Conditions which are associated with repetitive motion disorders are carpal tunnel syndrome, epicondylitis, DeQuervain's syndrome, thoracic outlet, shoulder tendinitis, cubital tunnel, ganglion, tendinits, tendosynovitis, ulnar nerve entrapment, white finger, trigger finger, neck tension, pronator teres syndrome (Kroemer, 1997).
      b. Low back problems have been associated with jobs in which workers handle heavy loads in a poorly-designed manner, while upper extremity disorders are more often associated with repetitive motions (Graves, 1992). Low back injury incidence can be reduced by ergonomic job redesign (Swartz, 1992).
      c. The US Bureau of Labor Statistics reported in 1994 that cumulative trauma disorders accounted for 6.8% of nonfatal injuries and illnesses in US businesses for 1994 (Kohn, 1994).
   3. Equipment manufacturers, the motor vehicle industry, the aircraft industry, grocery stores, the meatpacking industry, and men's and boy's clothing makers have the highest numbers of injuries (Kinsella et al, 1995; Grant et al, 1993; Johansson et al, 1993; Orgel et al, 1992; Harber et al, 1992). The Department of Labor's Bureau of Labor Statistics recorded that repetitive trauma cases have increased 1300 percent over the last 12 years (Kinsella et al, 1995).
      a. Nurses and nursing assistants have a high incidence of back injuries from patient transferring activities (Garg & Owen, 1992; Chavalitsakulchai & Shahnavarez, 1991; Garg et al, 1992). Physical therapists may have similar problems (Fenety & Kumar, 1992).
         1. TRAINING in proper lifting techniques, use of mechanical patient lifts, and avoiding abnormal postural stresses can decrease the injury incidence.
   4. High risk jobs include assembly tasks with cycle times of 30 seconds or less; or when more than 50 percent of the cycle time is spent performing the same fundamental motion (Kroemer, 1993). Such tasks include, amongst others, garment sewing, manual packaging, wiring, carpentry, typing, coil winding (Pulat, 1992), assembly operators, janitors, painters, electronics wiring technicians, masons, traffic controllers, and press operators (Eastman Kodak Company, 1986).
      a. A simple lengthening of the lifting hook used by forestry workers decreased energy demands by 12%, as well as decreasing peak load moments on the hips and lumbar spine (Hagen, 1993).
   5. Risky activities involve tasks which have repeated, rapid movements, static muscle loading, forceful movements that are less frequent, and vibration, aggravated by inappropriate postures. Posture and high force levels are highly significant factors (Kroemer, 1993).

B. OCCUPATIONAL RISK FACTORS
   1. EXTREME OR UNNATURAL JOINT POSITION
      a. It is recommended to keep movements at about the midpoint of the range of movement and to minimize unnatural positions, such as wrist deviation or extreme flexion or extension. Pinch and grip strength capabilities have been shown to decrease when the wrists are held in a deviated position (Halpern & Fernandez, 1993).
      b. Changing the wrist from a neutral position by twisting the forearm inward or outward while bending the wrist is very stressful. Maintaining a strong isometric contraction of the muscles, as when holding a hand tool, can lead to a repetitive motion disorder (Kroemer, 1997).
   2. FORCE

a. Hazards associated with forceful exertion depend upon the type of movement, what body part is exerting the force, and which other factors are involved (Joseph & Long, 1991).
b. High force levels may be considered a causative factor in development of CTDs (Kroemer, 1993). The use of the pinch grip requires four times more effort than the power grip (Halpern & Fernandez, 1993).

3. FREQUENCY OR REPETITION
    a. This refers to the cycle time. In general, a job will be considered repetitive when the cycle time is less than 30 seconds, or when more than 50 percent of the cycle time is spent performing the same fundamental motion(s) (Kroemer, 1993). Low-risk repetitive tasks have cycle times of more than 30 seconds, or less than 50 percent of the cycle time involved in the same fundamental motion(s) (Putz-Anderson, 1988).
    b. Hazards resulting from repetition depend upon the presence of other risk factors, and are associated with the continual use of the same muscular exertion(s) (Joseph & Long, 1991).
4. RECOVERY TIME
    a. This refers to the number of cycles per day or week (Konz, 1990). It is thought to be beneficial for keyboard operators to take rest pauses every hour (Kroemer, 1993).
    b. It has been suggested that CTDs occur in tasks with cycle times of 30 seconds or less (Pulat, 1992).
    c. Measuring the total recovery pulse is a good measure of workload. For an 8-hour workday, the first reading should not exceed 110 (pulses per min.) with a fall of at least 10 pulses between the first and third readings (Kroemer & Grandjean, 1997).
5. INDIVIDUAL FACTORS
    a. Preexisting conditions, such as individual variability issues, may also increase the risk (Pulat, 1992). A combination of these factors can further increase the level of ergonomic risk.
        1. Some individuals with arthritis, endocrinological disorders, Vitamin B6 deficiency, diabetes, pregnancy, oral contraceptive use, and gynecological surgery may be predisposed to have a cumulative trauma disorder (Kroemer, 1993).
6. STATIC EFFORTS
    a. During these muscular efforts, no useful work (motion) is seen, the blood supply is constricted, and blood does not flow through the muscle. In contrast, with dynamic efforts, a continual fresh blood supply is available to remove waste products through contraction and relaxation of the muscles.
    b. Heavy static work requires the muscle to use its own supplies of oxygen and nutrients, and waste products are not eliminated. Local hypoxia and lactic acid accumulation develop in the involved muscle, with resultant pain and fatigue (Grandjean, 1980).
    c. Characteristics of static efforts include high effort levels maintained for 10 seconds or more, moderate effort levels lasting for 1 minute or more, or slight effort levels (one-third of maximum force) lasting 4 minutes or more (Grandjean, 1980).
    d. Examples of static efforts include the following (Grandjean, 1980): Elevating the shoulders for long periods Holding items in the arms Pushing and pulling heavy objects Standing in one place for a long time Tilting the head forward for long periods
    e. It is estimated that work can be maintained for several hours per day without symptoms of fatigue if the force exerted does not exceed about 8 percent of the maximum force of the muscle involved (Grandjean, 1980).
7. MECHANICAL STRESS
    a. This is a risk factor associated with body contact with sharp, hard edges of work surfaces, tools, parts, or work units (Joseph & Long, 1991). Pressure on soft tissues by handles or tools causes the body to absorb the impact and the effects of vibration, and should be avoided (Fraser, 1989).
        1. In the poultry cutting industry, use of knives with a minus 30 degree angled blade have been shown to be superior in table cutting operations, while knives with a plus 30 degree angled blade are best for hanging cutting operations. Use

of improved knife designs can decrease the incidence of CTDs (Fogelman et al, 1993).

8. TEMPERATURE
    a. Exposure to cold air, drafts, tool exhaust, and cold tools can decrease the dexterity of the hands and impair the sense of touch. Overexerting muscles to grip work tools may increase the ergonomic risk. Heat stress from hot, humid work environments can increase whole-body physical strain and result in heat exhaustion and heat stroke (Joseph & Long, 1991).
    b. Temperature extremes must be controlled to allow the operator's body to acclimate. Extremes in temperature cause problems to the core temperature (Kohn, 1997). c. Refer to the THEMRMAL STRESS INFOTEXT(R) document for more information.
9. VIBRATION
    a. The use of powered hand tools can lead to exposure to vibration, which has been shown to cause damage to blood vessels, nerves, and the bones of the arms and hands (Joseph & Long, 1991).
    b. White finger disease, or Raynaud's syndrome, is caused by using vibrating tools in a cold environment. Numbness and tingling first occur, and if allowed to continue, a loss of all feeling and control in fingers and hands will result (Kohn, 1997).
    c. Refer to the VIBRATION SYNDROME INFOTEXT(R) document for more information.
10. OTHER RISK FACTORS
    a. Lack of freedom of action is considered a risk factor, when the operator's work is completely governed by someone else. Work content and learning are considered other risk factors, when the operator performs only one task and does not have an opportunity to learn a variety of skills or tasks (Heden et al, 1993).
    b. Additional factors include social aspects of the organization, uncontrolled disturbances, piecework, weight of the work unit (Heden et al, 1993), and shiftwork (Schonfelder & Kanuth, 1993).

C. RISK FACTOR REDUCTION SUGGESTIONS
1. Certain conditions should be avoided to reduce risk factors which could lead to cumulative trauma disorders (Tayyari & Emanuel, 1993). The ultimate goal is to design the job to fit the person.
    a. Job tasks should be modified to reduce or eliminate repetitive activities: reduce awkward postures by redesigning work tasks and tools; alternate positions; and do not maintain static postures for extended periods of time.
    b. Minimize static loading (Fraser, 1989) by: avoiding extended efforts of holding, carrying, or lifting; standing in one position; extended reaches; pushing or pulling heavy objects; excessive backward or forward bending; using unnatural hand grips on tools or equipment; forward or backward head inclination; and, sitting without proper back support (Alexander & Pulat, 1985).
    c. Proper training is very important in reducing the risks of CTDs. Proper equipment, controls, chairs, and prevention aids should be used. Engineering controls go hand-in-hand with administrative controls (Kohn, 1997).
2. Avoid work that requires repetitive or prolonged exertion of more than one-third of the operator's static muscular strength available for that activity (Kroemer, 1993). Avoid hard surfaces or sharp edges on work surfaces or tools that contact body parts. Reduce exposure to cold environments or drafts and eliminate continual exposure to vibration.
3. Eliminate pinching tasks and spread the load over many muscle groups, minimize time or pace pressures, avoid extreme wrist or arm deviation, keep forces low, provide a variety of tasks during the shift which work various muscles, allow time for people to adjust to new tasks, and provide fixtures and proper tooling to reduce awkward positions and forces (Eastman Kodak Company, 1986).
4. Aim to reduce stress on the operator's body by analyzing job tasks and activities. Examine all work elements to reduce ergonomic risk factors and redesign work to allow the operator to work in a neutral posture. Design the workstation so that it is compatible with the dimensions and capabilities of the worker population.

    a. It is helpful to allow the worker to alternate between seated and standing tasks. Adjustable work surfaces are recommended, and it is important that the work surface be about two inches below the elbow when standing or seated (Alexander & Pulat, 1985).
        1. In F-16 Fighter Pilots, the backward inclination of the backrest differs from the usual pilot neutral seated posture. Decreasing flight helmet weight and shifting the center of body mass backwards can reduce neck strain (Hoek van Dijke et al, 1993).
5. Additional principles for reducing and/or eliminating ergonomic risk are as follows (Dul and Weerdmeester, 1994; Tayyari & Emanuel, 1993): 1. Avoid bending forward 2. Maintain neutral positions 3. Keep the work close to the body 4. Alternate movements and postures 5. Limit continual muscular effort 6. Reduce sudden movements 7. Eliminate twisting motions 8. Prevent muscular exhaustion 9. Include frequent short breaks into activities 10. Limit energy expenditure 11. Rest after heavy activities 12. Incorporate anthropometric data into the design of work tasks 13. Alternate sitting with standing and walking 14. Provide proper instructions on adjustable equipment and new tools 15. Utilize chairs with adjustable seat height and back rests 16. Utilize chairs, equipment, and tools for the operator and the job 17. Avoid excessive reaches 18. Remember the work height depends on the activity 19. Consider sloping work surfaces for reading activities 20. Utilize adjustable worksurfaces 21. Limit platform use 22. Offer variations in tasks 23. Utilize the appropriate tools: Bend the tool, not the wrist 24. Suspend heavy tools if possible and maintain equipment 25. Pay attention to handgrips of tools 26. Avoid working above the shoulder and behind the body 27. Reduce manual lifting when possible 28. If heavy lifting cannot be avoided, alternate tasks with light jobs 29. Ensure that people always lift less, much less, than 23 kg 30. Utilize NIOSH guidelines to analyze lifting tasks 31. Make sure the loads are not too light that require frequent lifts 32. Utilize proper lifting techniques; train operators on lifting 33. Use lifting accessories, limit the load, use proper handgrips 34. Limit pushing and pulling forces; use body weight to push or pull 35. Maintain floor surfaces
6. ADDITIONAL GUIDELINES
    a. Reference: (Konz, 1990)
    b. Minimize upper arm abduction to protect the shoulder. Keep the upper arm vertical and downward and don't lift above the head.
    c. Don't bend the wrist in manipulative work. Keep the wrist in a neutral position. Orient tools and fixtures to maintain the neutral position.
    d. Minimize reaching behind the back. Keep items in front of the body and not behind or far back at the sides of the body.
    e. When analyzing problem jobs involving manual material handling, utilize the NIOSH Work Practices Guide for Manual lifting.
        1. NIOSH WORK PRACTICES GUIDE FOR MANUAL LIFTING
            a. Reference: (Herrin, 1991)
                1. The NIOSH Lifting Guidelines have been judged to be BETTER than the European Coal and Steel Community (ECSC) Force Limit Value(s) for sagittal plane 2-handed lifting (Henderson & Dutta, 1992).
            b. Established by NIOSH in 1981 on the basis of four criteria: Epidemiology Biomechanics Psychophysics Physiology
            c. Factors included in the guideline are the following: Object weight (W) Horizontal location of the hands (H) Vertical location of the hands (V) Vertical travel distance (D) Frequency of lifting (F) Maximum frequency in lifts per min that can be sustained (Fmax) Duration or periods of lifting (P)
            d. The following equation describes a lifting task performed in front of the body, with an item less than 30 inches wide, lifted smoothly, and with no additional carrying or walking. The resulting action limit (AL) describes the weight which should be lifted.
            e. The equation is as follows: AL (lbs)= 90 x (6/H) x (1.0 - 0.01 (V - 30)) x (0.7 + 3/D) x (1 - F/Fmax)

f. The GUIDE is available from: The American Industrial Hygiene Association, 475 Wolf Ledges Parkway, Akron, Ohio 44311, (216) 762-7294 (Herrin, 1991).

2. REVISED NIOSH GUIDE FOR MANUAL LIFTING
   a. Reference: (Garg, 1994; Kroemer, 1997)
   b. The 1981 Guideline was revised and expanded in 1991 to be applied to a greater number of lifting tasks.
   c. Criteria established under the new guides are as follows: Recommended weight limit in pounds (RWL) Load constant of 51 (LC) Horizontal distance of the hands away from the mid-point between the ankles in inches (H). Multiplier HM equals 10/H. Vertical height of the hands above the floor in inches (V). Multiplier VM equals (1 - 0.0075 (V-30)). Vertical travel distance of the hands between the origin and the highest point of the lift (D). Multiplier DM equals (0.83 + 1.8/D). Asymmetric angle is the angle between the asymmetry line and the mid-sagittal line (A). Multiplier AM equals (1 - 0.0032 x A). Coupling multiplier is taken from a table and depends on whether the handles are good, fair, or poor (CM). Frequency factor is defined as the frequency of lifts taken from a table which lists the work duration and vertical distance in association with the number of lifts per minute (FM).
   d. The Equation is represented by the following: RWL = LC x (10/H) x (1 - 0.0075 (V-30)) x (0.83 + 1.8/D) x (1 - 0.0032 x A) x CM x FM or; RWL = LC x HM x VM x DM x AM x CM x FM
   e. The load constant represents the maximum weight to be lifted or lowered under ideal conditions and the multipliers are used to decrease the load constant.
   f. The equation applies to the following situations (Kroemer, 1997): Motions are slow, smooth, and continuous The load is held with two hands The time duration of lifting and lowering is between 2 to 4 seconds Motions are performed manually without the use of a mechanical aid Temperature and humidity are moderate, posture is unrestricted, foot traction is adequate, and the horizontal distance between two hands is not more than 25 inches.
   g. OTHER MANUAL MATERIAL HANDLING ACTIVITIES
      1. Reference: (Pulat, 1992)
      2. Upper force limit for pulling and pushing tasks in a standing position: 225 Newtons
      3. Upper force limit for pulling and pushing tasks in a seated position: 130 Newtons
      4. Design for an upper limit force of 68 Newtons for a lateral or transverse push using only the shoulder muscles.
      5. Lowering activities are stressful. Compared to lifting, assume a 3 to 5 percent increase for the population capability.
      6. A 12 to 15 kilogram weight can be carried by both hands for distances up to 40 to 50 meters.
         (a) Carrying loads can affect the body in different ways. Carrying with one hand is not recommended since this is very fatiguing; distributing the load across the chest and back is not as stressful, as this requires less energy. Maximam load weight is between 25 to 30 kilograms. Always make sure to carry the load waist high and near the mid-axis of the body.
      7. An upper limit of 540 Newtons should be used for a pull-down activity above head height when in a standing posture. At shoulder level, 315 Newtons is the limit. A push down force of

287 Newtons can be applied safely at elbow height. Adjust these values 15 to 20 percent for seated posture.