# Ergonomics

## Principles, Foundations and Analysis

Course developed by:
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## Course Developer and Presenter

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Mark A. Anderson is the president and founder of ErgoSystems Consulting Group, Inc., a Minneapolis, Minnesota based ergonomics consulting group. He is also the co-founder of RealErgo, Inc., a DVD and internet based provider of ergonomics related instructional materials.

Anderson is board certified as a professional ergonomist by the Board of Certification in Professional Ergonomics. His background also includes licensure as a physical therapist. He has consulted in ergonomics for over 20 years.

Anderson has developed and implemented ergonomics strategies for a wide range of companies and organizations. (Tennant Company, General Electric, Emerson Process Management, Medtronic, St. Jude Medical, DSI, Marvin Windows, ATK, Quaker Oats, Pepsi-Cola, General Mills, Fingerhut, Bureau of Engraving and Printing, Panama Canal Commission, United States Navy and Marine Corps, United States Customs Service and state and local governments.)

With an emphasis on a systems approach to ergonomics, Anderson has worked with architectural and engineering design firms to integrate ergonomics principles into the design process. Adding the elements of ergonomics (including Work Physiology, Engineering Psychology, Epidemiology, Anthropometry and Occupational Biomechanics) as part of the design equation enhances the effectiveness of the overall process and final outcome.

He has written a number of publications and spoken nationally and internationally on ergonomics. He has been active in the Upper Midwest Chapter of the Human Factors and Ergonomics Society serving as the past President, Secretary and Co-program Chair.

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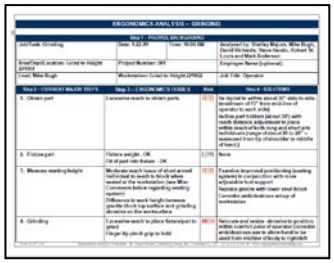
## SETTING THE STAGE

### Course Content and Objectives

**Ergonomics: Principles, Foundations and Analysis** offers a framework to **perform ergonomics analyses** and **generate reasonable and feasible recommendations**.

#### *Ergonomics Analysis Process*

You will learn how to use a five part **Ergonomics Analysis Process**:



- **Step 1**: Gather and document **BACKGROUND INFORMATION**.
- **Step 2**: Describe the job/task and outline **CURRENT MAJOR STEPS** to complete the job/task.
- **Step 3:** Compare present job/task steps to a set of Ergonomics Principles to identify **ERGONOMICS ISSUES**.
- **Step 4**: Develop and implement realistic and feasible **SOLUTIONS**.
- **Step 5**: **FOLLOW-UP**: evaluate outcome and make needed changes.

The ergonomics analysis process is based on a fundamental knowledge of ergonomics principles and applications. Through interactive lecture and a strong emphasis on case studies the course presents a systematic approach to ergonomics analysis.

#### *Ergonomics Principles and Foundations*

We define a set of **Ergonomics Principles and Foundations.** The principles can be applied to any ergonomics analysis. The foundations provide objective rationale to support the principles.

#### *Ergonomics Analysis and Problem Solving*

Next we delve into **ergonomics analysis and problem solving** with a look at problem solving principles and the components of an ergonomics 'Tool Box'. The Tool Box includes a list of recommended equipment, materials and forms to conduct and document the analysis.

#### *Ergonomics Case Studies*

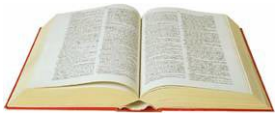
To pull the concepts together a series of cases studies are included for **hands-on practice and feedback**.

#### *Resources*

Also included is a list of ergonomics related resources and references.

## FIRST OF ALL . . . WHAT IS ERGONOMICS?

### Definition of Ergonomics



The word '***ergonomics'*** was coined by a Polish scholar in 1857. In Greek 'ergon' means work and 'nomos' means the laws or study of. So, ergonomics is literally the ***"the laws or study of work."***

#### *Ergonomics – What is the Goal?*

We all would agree that the goal of ergonomics is to improve the health, safety and productivity of activities – whether at home or at work. We would also agree that aspects of physical and mental stress contribute to the factors of health, safety and productivity.

**Is the goal of ergonomics to . . .**

**eliminate physical and mental stress?**

**Eliminate physical stress** . . . what is the outcome? We are aware that if physical stress is eliminated (bed rest, for example) the result is disastrous. (If you don't use it . . . you will lose it!) And of course we also realize that excessive physical stress without time for adequate recovery is equally problematic.

**Eliminate mental stress** . . . what is the outcome? As it turns out . . . not much! We recognize that some mental stress acts as a motivator. But we also know that too much mental stress results in decompensation and dysfunction.

How about if we replace the word **ELIMINATE** with **OPTIMIZE**.

- **OPTIMIZE physical stress**
- **OPTIMIZE mental stress**

A whole different connotation is appreciated. Think of it as the 'stress continuum'; a certain window of optimization is apparent.

- **Too much . . . a problem!**
- **Too little . . . a problem!**
- **Just right . . . the goal!**


**The Stress Continuum**

Here is a critical question . . .

**Is the 'JUST RIGHT' window the same for each person?**

Or is it true that what may be **TOO MUCH** for one individual is **JUST RIGHT** and very acceptable for another?

And how about . . .

**Do other factors influence the 'JUST RIGHT' window?**

Factors like the time of the day, fatigue, work station design, tools and equipment, training, environmental conditions, supervision - this list can go on and on - also impact the **JUST RIGHT** window.

The true challenge of ergonomics analysis is to recognize the influence of individual variation **AND** figure out how best to deal with them to optimize performance.

### *What is ergonomics and how can it make a difference?*

## Ergonomics and Gravity

**Ergonomics is like throwing a ball into the air.**

**What happens?**

**Correct!**

**The ball comes back down.**

**Why?**

**Gravity works!**

In fact, if it didn't come back down, we would be quite surprised! As we understand the laws of gravity, when we stand on the face of the earth and throw a ball into the air, it will come back down. In other words the **CIRCUMSTANCES DICTATE THE REPONSE.**

Now, imagine we **DON'T** want the ball to come back down. What do we need to do? How about throw the ball up and just tell it to stay in the air . . .

**BALL - STAY UP!!**

Everyone will agree this is **LUDRICOUS**. You can't get a ball to stay in the air just by telling it to.

Rather you need to change something . . . attach Velcro to it, throw it into a net, attach it to a string, launch yourself into outer space . . . you get the picture!

How does this relate to what ergonomics is all about?

### *Circumstances predict the response!*

Well, rather than throw a ball into the air, let's say you bend over to assemble a component at a low level. The body position most likely used is to just bend over at the waist.

From a health and safety, as well as productivity standpoint, we recognize this work position can cause problems. But unfortunately it is a commonly observed work position.

How about this for a solution - whenever we see someone in this poor position we tactfully tap them on the shoulder and say,

**'When you are in that bad position, be really, really, really careful you don't hurt yourself!'**

That makes about as much sense as telling the ball to,

**'Just stay in the air!'**

A much better solution is to. . .

**CHANGE THE CIRCUMSTANCES TO CHANGE THE RESPONSE!**

We could reposition either the assembler or the work – for example use a rolling stool.

What are some other options?

1. _____

2. _____

3. _____

Given a certain set of circumstances, we will typically respond in a predictable way.

**If we want to change the RESPONSE**
**We need to change the CIRCUMSTANCES!**

**ERGONOMICS . . .**

**The optimization of all aspects of job performance - *safety, quality and productivity* - accomplished through the appropriate *design and use* of work stations, work processes and the overall organization of work.**

### *Why does Ergonomics Work?*

Ergonomics works because it:

- Uses strategies to identify and solve problems.
- Is design based; it addresses the true root cause not just the symptoms.
- Is cost-effective; it incorporates an incremental approach to interventions.
- Makes use of the best ergonomists in the world . . . people who actually do the work!

## Systems Design

The essence of ergonomics is design. Design of work stations, work processes, work environment and work culture dictates the level of safety and productivity. For example, effort may be wasted because of:

- Poor positioning of tools, equipment and parts.
- Poor design or maintenance of tools.
- Haphazardly thought out work processes.
- Poor work environments due to poor ventilation and lighting.
- Non-responsive management systems and work culture.

You can effectively deal with these problems and other problems by using ergonomics. A systems design approach provides a solid foundation.

### *A little mind reading!*

To get a handle on the concept of systems design . . . get out your crystal ball and try this example.

| STEP | ACTIVITY | RESULT |
|---|---|---|
| One: | Choose a number between one and nine. | |
| Two: | Multiply that number by nine. | |
| Three: | Add together the digits of the result of Step Two. | |
| Four: | Subtract five from the result of Step Three. | |
| Five: | Choose the letter of the alphabet that corresponds to the result of Step Four, e.g., A=1, B=2, C3, etc. | |
| Six: | Choose a country that begins with that letter. | |
| Seven: | Choose an animal that begins with the last letter of that country. | |
| Eight: | Choose a color that begins with the last letter of the animal. | |

**This is a good design of a system; let's discuss why.**

### *Systems Design: Principles*

The Human Factors Design Handbook defines a system as:

**A system is a mission-oriented grouping of elements into an integrated, functional whole.**

**The system typically includes a facility, equipment, furnishings, and fixtures and involves a variety of people who use, operate, or maintain it.**

**The system must perform a mission or function and must work in an environment.**

### Country-Animal-Color

The ***Country-Animal-Color*** exercise you just completed yields a consistent response for a majority of people based on a set of principles that make up a system. (Or, if you choose to you can believe it really is possible to read minds!)

A set of general principles of the Systems Design approach includes:

- The system is adapted to the human
- The system facilitates the highest level of performance to which the operator is capable
- The system optimizes physical and mental stress imposed on the operator
- The system provides personal satisfaction for the user in terms of use
- The system and its components function to serve the human
- The system recognizes individual variation in human capabilities and limitations
- The design of the system influences human behavior either positively or adversely
- A system, by definition, does not exist in isolation

**Human Factors Design Handbook, 2nd Edition**
Woodson. Tillman and Tillman
McGraw-Hill, Inc., New York, NY, 1992

### *Systems Design: Foundations*

The study of systems design encompasses many fields. For our purposes we will examine several that have direct influence on ergonomics. Each of them is a full-fledged discipline. As we introduce the ergonomics principles we will discuss:

- Epidemiology
- Work Physiology
- Engineering Psychology
- Anthropometry
- Occupational Biomechanics

## ERGONOMICS PRINCIPLES AND FOUNDATIONS

Based on our discussion we will develop a general set of **Ergonomics Principles**. Here is a summary of the Ergonomics Principles and Risk Level Index.

### Ergonomics Principles

1. **PROCESS** – Promote effective work processes
2. **POSITION/SUPPORT** – Promote neutral body and limb position/support
3. **MOVEMENT** – Promote regular physical movement
4. **MATERIAL HANDLING** – Control manual material handling
5. **REACH** – Promote work in reach zone
6. **WORKSTATION/TOOLS/EQUIPMENT** – Provide correct workstation, tools and equipment
7. **TRAINING** – Provide competency based training
8. **ENVIRONMENT** – Control exposure to work environment
9. **HEALTH/WELLNESS** – Promote personal health and wellness
10. **FEEDBACK** – Provide on-going feedback for continuous improvement

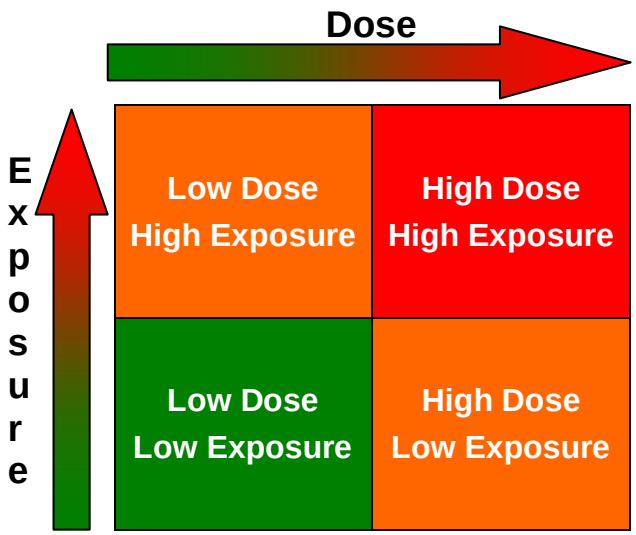
### Risk Level Index

The key establishes the **Risk Level Index** in terms of ergonomics issues (health, safety and productivity): **NOTE**: Ranking may be subject to change based on additional input.

- **LOW** considered **low** risk with low priority to change.
- **MOD** considered **moderate** risk, recommend modification as feasible.
- **HIGH** considered **high** risk, recommend concerted effort to modify.

**Risk Level Index** takes into account **Dose** (severity/stress level of the ergonomics risk factors) in combination with **Exposure** (duration/frequency of the ergonomics risk factors).

The higher the values for Dose and Exposure the greater the estimated risk.



## Promote Effective Work Processes

The overarching principle of ergonomics focuses on promoting the effectiveness of the work process itself. This principle is a wide ranging one that addresses the work process in total.

The goal is to take a step back and really examine why something is done as it is. If the answer is . . .

"***Because it has always been done that way!***"

It may be worth the effort to take a fresh look. Is there a better way to get it done?

What we see day after day becomes common place to use. We simply don't pay attention anymore. We can't see the forest because of the trees.

Recall we defined ergonomics as:

**The optimization of all aspects of job performance - *safety, quality and productivity* - accomplished through the appropriate *design and use* of work stations, work processes and the overall organization of work.**

By optimizing job performance we have a dramatic impact on the effectiveness of the work. While buzz words come and go:

- Lean
- Continuous Process Improvement
- Value Stream Mapping
- Kaizen Events
- Six Sigma
- 5S+1

In one way or another, these types of strategies encompass the goal of promoting effective work. This is what Ergonomics is all about. Ergonomics is now recognized as an essential component and business tool in organizations across the country and the world.

### *Effective Work Process Metrics*

One of the important components of the ergonomics process is to establish a picture of the present state of affairs. Part of this is an examination of the company's record of injury/illness reports, productivity reports, quality reports, etc. This information can:

- Establish an injury and illness baseline against which future interventions can be measured

- Provide guidance for allocation of resources
- Compare a particular company to industry wide statistics
- Provide for work force input to enhance communication

Typically this can be a reactive records review and/or proactive data collection.

### Reactive Records Review

One way to think of a reactive records review is the 'iceberg' analogy. Ten percent of the iceberg floats above the surface and is visible. This equates to the reactive records review that includes OSHA logs, medical records, productivity records, insurance records and payroll records.

### Proactive Data Collection

Proactive data collection provides a means of evaluating the ninety percent of the iceberg still below the surface. Rather than evaluating what has happened in the past, we attempt to glean information from what workers are currently feeling and experiencing. The advantages of doing a proactive data collection and analysis include:

- Identification of hazards prior to an incident
- Revelation of gaps in the record keeping process
- Identification of pre-clinical cases
- Indication of the number of workers affected within a particular department to aid in prioritization of resources

So whatever strategies you currently apply, ergonomics can help them be even more successful. All of the ergonomics principles directly relate to factors to optimize job performance.

## *Designing Effective Work Processes*

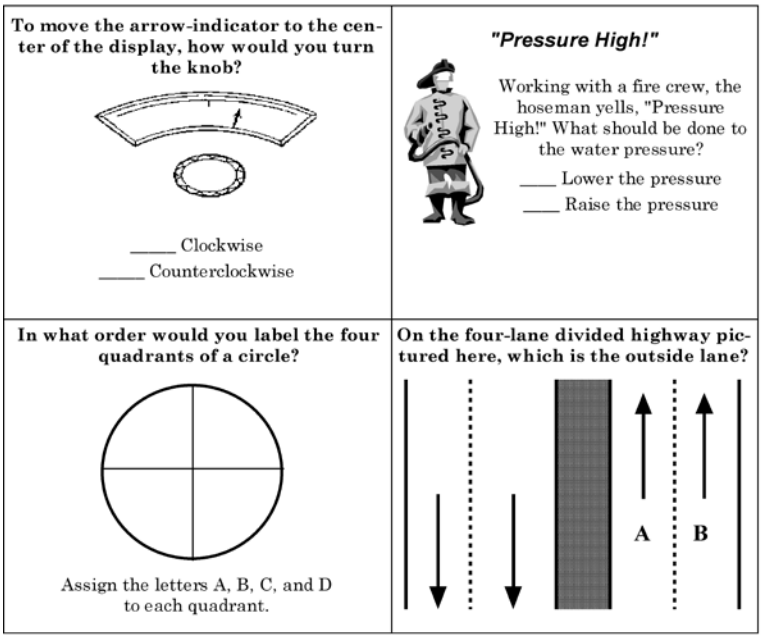
### Population Stereotypes

The practice of ergonomics has sometimes been described as the application of common sense to the situation. "Common sense" is an interesting concept.

This implies that we all have the same sense in common.

Here is an exercise that may shed some light on the validity of the 'in-common' common sense hypothesis.

As you have just discovered, we do not have the same "common sense." Our view



of the world is greatly shaped by our experiences. Falling back on the, **"Well, it is just common sense!"** will not provide the desired consistent and reliable result we are striving to achieve.

## Design Conventions and Human Behavior

Engineering psychology involves designing systems with information processing capabilities and limitations in mind. Once again, optimizing performance is the objective.

A crucial aspect of a good systems design involves understanding and applying design conventions and human behavior.

### *Overload/Underload*

As technologies become more complex, systems may overload human information processing capabilities.

- For example, a typical telephone number with the area code is 10 digits long; too long for most people to remember it long enough to dial it.
- Fighter jet pilots have been known to actually shut down some of their displays to control the amount of information they receive.

Can a job be too boring?

- A job that lacks reasonable challenge results in problems.
- Workers are not challenged to stay on task and minds tend to drift with potentially very serious consequences.

### *Previous Experience*

Accurate information processing is also predicated on future expectations based on previous experiences.

For instance, it does absolutely no good to pound on the center of the steering wheel of a 1983 Ford LTD station wagon to warn the driver of the car that is about to back into you. (Depressing the turn signal stalk activates the horn **NOT** pushing on the steering wheel.)

Based on an understanding of behavior it is possible to design a tool, work station, work process, and work environment in a manner that enhances performance.

## Effective Work Process Design Principles

Donald Norman, in ***The Psychology of Everyday Things***, outlines relevant basic principles of design in a practical manner:

**The Principles of Everyday Things**
Norman, Donald A.
Basic Books, Inc. New York, 1998

### *Design for good visibility*

Make it visually apparent what the control on a piece of equipment does.

**Application example:**

- Many people never learn how to program their DVD players or fully use the features of their telephones. The controls, by themselves, are not visually apparent.

*Apply the principles of mapping*

Make clear the relationship between two things - between controls, their movements, and the results in the real world. Make use of physical analogies and cultural standards.

- To steer a car to the right, turn the wheel to the right.
- An indicator moving up means an increase in volume.
- An indicator moving from left to right means an increase in volume.
- Push a light switch up to turn on the light. (Is this always true?)

**Application example:**

- If a number of indicators are monitored to be in the safe range, design all of the indicators to be in the same position when in the safe range, one that moves out of the safe range is quickly identified.

*Provide feedback*

Return information to the user regarding the outcome of user actions. The problem becomes even more significant when more features are available but less feedback is provided.

**Application example:**

- Without adequate feedback, how do you really know you have correctly programmed your alarm clock?
- Or entered correct number in your cell phone?
- Or entered the correct code into the ATM?

## Effective Work Process Design Principles – Synopsis

### *Design Conventions*

- Avoid operator overload (as well as underload)
- Previous experience influences future performance

### *Design Principles*

- Visibility – design for good visibility for operation
- Mapping – make sure the relationship is clear
- Feedback – provide to user regarding outcome

### *Work Process Design Checklist*

Refer to the ***Addendum - Work Force, Work Station and Work Process*** at the end of the manual for additional specific information.

Use the ***Work Process Design Checklist*** as needed for the ergonomics analysis process.

# Work Process Design Checklist

**"YES" response indicates potential problem area that should receive further investigation.**

| | | | |
|---|---|---|---|
| **Is the task complex?** | | | |
| **1.** Does worker have to evaluate data before taking action? | YES | NO | NA |
| **2.** Must operator sense and respond to information signals occurring simultaneously from different machines without sufficient time to do so? | YES | NO | NA |
| **3.** Must operator process information at rate that might exceed capability? | YES | NO | NA |
| **4.** Is job so complex it takes a long time to train workers? | YES | NO | NA |
| **5.** Does task require a great deal of accuracy? | YES | NO | NA |
| **6.** Does work situation require monitoring several machines? | YES | NO | NA |
| **Is the task monotonous?** | | | |
| **7.** Does the worker repeat same task without change for entire shift? | YES | NO | NA |
| **8.** Does the worker lose track of task at hand because it is overly monotonous? | YES | NO | NA |
| **Design and Use Standards** | | | |
| **9.** Are controls standardized on similar equipment? | YES | NO | NA |
| **10.** Does design of any instrument increase reading errors? (Dials and instruments difficult to read quickly and accurately) | YES | NO | NA |
| **11.** Are controls difficult to reach and operate? | YES | NO | NA |
| **12.** When all readings are correct, do pointers in a group of dials point in different directions? | YES | NO | NA |
| **13.** Are dials grouped inconveniently? | YES | NO | NA |
| **14.** Is dial too complex for level of information required? | YES | NO | NA |
| **15.** Is it difficult to see immediately how a control is set? | YES | NO | NA |
| **16.** Does reading instruments require a lot of head or body movement? | YES | NO | NA |
| **17.** Does worker's hand obstruct dial when operating controls? | YES | NO | NA |
| **18.** Is there a need to tell difference between parts by touch? | YES | NO | NA |
| **19.** Is it difficult to recognize controls and tools by touch and/or position? | YES | NO | NA |
| **20.** Does the task require fine visual judgments? (Includes need to detect small defects, judging distances accurately) | YES | NO | NA |
| **21.** Are controls, instruments and equipment placed where they are difficult to see? | YES | NO | NA |
| **22.** Are warning lights located out of center of field of vision? | YES | NO | NA |
| **Training (Technical and Safety)** | | | |
| **23.** Is the workforce inadequately trained in the technical aspects of the job process and demands? | YES | NO | NA |
| **24.** Is the workforce inadequately trained in the safe performance of the job tasks? | YES | NO | NA |
| **25.** Is the workforce inadequately trained in methods (breaks, stretching, and warm-up activities) to control job fatigue | YES | NO | NA |

## Promote Neutral Position and Support

The next principle is to position and support the body and limbs in neutral.

### *Neutral Position*

One way to think about the neutral position is to consider what really is the foundation of the body?

Is it the feet? Consider if you sprain an ankle . . . by using a pair of crutches you can still get around.

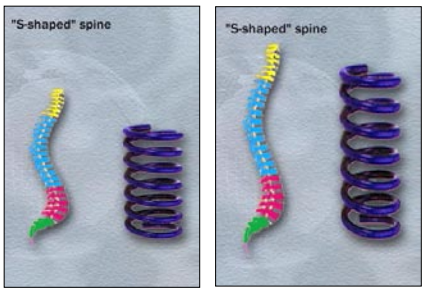
On the other hand what if you "sprain" your back? You might know someone who's been in this condition – they have a significant problem even getting out of bed to get to the bathroom.

The foundation or core of the body truly is the spine and pelvis. This directly relates to the position of the body in general and to posture in specific. With the spine and pelvis in a good position this allows us to make good use of our legs and arms.

### Spine neutral position

What is the neutral spine position?

A neutral spine is in an S-shape: inward curves in the low back and neck; outward curve in the midback.




The advantage is that the spring like shape is able to better deal with compression and shear stresses in the spine.

**Benefits**:

- Decreased biomechanical strain
- Increased respiratory function
- Improved range of motion

### Arm/hand neutral position

What is neutral for the arms and hands? Neutral is the midrange of joint position. For the arms/hands this is with the shoulders relaxed, elbows at the sides flexed to about 90 degrees and the hands positioned with the thumbs pointing up.

*Can you position yourself 100% of your time in neutral?*

*Of course the answer is **NO**!*

*But how about 15%?*

*In many situations it is very feasible to significantly improve the situation to increase neutral position and support by about 15%.*

*15% more time in neutral with good support can significantly decrease the level of stress into the body's tissue, enhance performance and increase comfort levels.*

*We encourage you to become a charter member of the 15% Club!*

## *Support for Body Weight and Limbs in the Neutral Position*

### Seated

With the body and limbs positioned in neutral the second part of the principle is to provide suitable support for the weight of the body and limbs.

Inadequate and improper seated support creates problems. People sit on their legs on the chair. They cross their legs for extended times.

Compression of the soft tissues occurs with a decrease in blood flow and circulation. Proper seated support is critical.

*In fact even well supported seated posture becomes uncomfortable quite quickly. How long do you sit in one position before your body gives you a signal to move?*

### Limbs

Proper support for the limbs (for example, chair armrests) removes the strain of weight bearing and also unloads the neck, shoulders and back.

*Hold your arms half way out in front of you. How long can you do it before you experience discomfort and fatigue?*

### Standing

Unsupported standing for extended periods is not desired.

Joint compression occurs, actually decreasing the amount of joint space and not allowing adequate joint lubrication. Fluid tends to pool in the lower extremities.

The bottom line . . . it is tiring!

*In fact as individuals we try very hard to eliminate sustained unsupported standing.*

*Look at people standing in a line. What do you see them do to obtain relief?*

## Promote Dynamic Physical Movement

This ergonomics principle promotes dynamic physical movement in the workplace on an on-going basis.

### *Stand or Walk?*

Most people have carried a backpack at some point. Picture this scenario - you are with a group of friends going for an extended hike; your backpack weighs 50# and you have put it on your shoulders.

What would you rather do: stand in one place for the next 20 minutes OR take that same backpack and start to walk for a few miles?

To a person, everyone agrees that it is much better to walk – not to stand. We intuitively know that movement is superior to maintaining one position. In other words, we need to move to be comfortable.

That is what this ergonomics principle is all about and there are sound physiological reasons why this is the case.

### *Metabolism (Work Physiology)*

To accomplish work, the body is able to take in nutrients, convert them into chemical energy and then ultimately into mechanical energy (e.g., muscular contraction) and heat. This is called metabolism.

Glucose and oxygen are stored in relatively small amounts within the muscle tissue. Consequently, to sustain performance continuous flow of oxygen and energy-rich blood into the tissue in addition to removal of metabolic waste products is required.

### Static Muscle Contraction

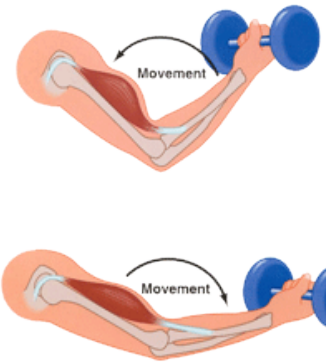
Type of muscular effort has been shown to have a profound impact on blood flow.

Static muscle contractions (the muscle shortens but no joint movement occurs) results in blood vessel compression due to internal muscle pressure.

At contraction levels of 60% and greater of the maximum voluntary contraction of the muscle, blood flow ceases.

The muscle depends on the quite limited initial reserves stored internally. Waste products accumulate and only short duration contractions are possible.

### Dynamic Muscle Contraction




On the other hand dynamic muscle contractions are the alternating contracting and relaxing of muscle groups to perform tasks.

In terms of enhancing performance and controlling fatigue, dynamic muscle contractions are a significant improvement over static muscle contractions.

Dynamic muscle activity promotes blood and fluid flow by acting as a pump to increase oxygen and nutrition to the working muscles and helps to remove the waste products of metabolism.

### Position—Sustained/Awkward

Metabolic fatigue also occurs as the result of sustained position.

- Blood flow—both volume and rate of flow—decreases.
- Pooling of fluid in the extremities occurs.

The body's tissues require ongoing nutrition even at low or minimal activity levels. The position of the body when sedentary has impact. Sustained awkward positions result in:

- Muscular contractions to maintain the position.
- Potential decrease in blood flow due to internal impingement or external contact stress.

### *Metabolic/Work Physiology Synopsis*

### Movement/activity

- Promote dynamic not static muscle contractions
- Build-in adequate physical recovery times
- Incorporate movement into the work process

### Position and support

- Design for neutral positions
- Design for body/limb support at work stations

## Promote Work in Reach Zone

### *Hand Use*

### How much do you use your hands every day?

More than half the day? How about more than 75% of the day? Well in fact, most people will say they use their hands at least 99.9% of the day!

### Where do we tend to use our hands?

For example does anybody work behind their back? Pretty hard to see what you're doing!

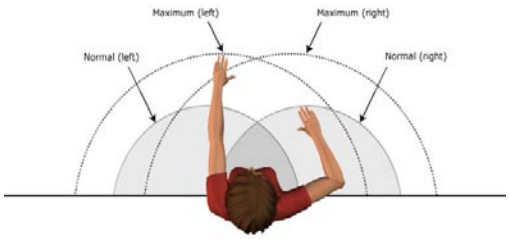
Because in most cases we need to see what we are doing we tend to use our hands in front of and to the sides of our body. We can define two reach zones:

1. **Comfort Reach Zone**
2. **Functional Reach Zone**

### Comfort Reach Zone

Think of the comfort reach zone as that area in front and to the side where you'd like to use your hands when you're doing precise hand activity.

The dimensions of the Comfort Reach Zone will be determined by your forearm length. To get a feel for this, position your elbows at your sides with your elbows bent at about 90°, swing your hands from side to side.



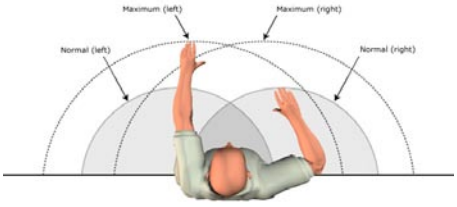

The height of this reach zone will be about three or 4 inches above and below double level. This is your Comfort Reach Zone.

Typical activities in the Comfort Reach Zone will include keyboard and mouse use along with handwriting. This also includes precision assembly in a manufacturing environment where you may exert a minimal downward force.

### Functional Reach Zone

Think of the Functional Reach Zone as that area in front and to the side were you be able to comfortably reach to obtain parts and materials.

The dimensions of the Functional Reach Zone are determined by your arm length. An easy way to get a feel for this is to reach your arms out in front of your body with your elbows straight. From your shoulder to the middle of your hand is your forward functional reach.




Now swing your arms out to the side about 45° from the midline of your body. This is the side to side functional reach.

Drop your hands so they are relaxed at your sides. This is called knuckle height and is the bottom zone of the functional reach.

Finally with your arms extended raise them so they are about shoulder level. This is the upper zone of the functional reach.

Stature and arm's length determine the reach zones. Determine the individual reach zones and set up the work station to promote reaches in the appropriate zones.

*Reach zone is really of function of lever arms. The longer the lever arm, the greater the force that is imposed on the body. How long can you hold 10 pounds at arm's length compared to the exact same 10 pounds held close to your body*

### *Anthropometry*

How can we determine how far a person can reach? Well we could actually go measure the individual to determine what their capability is. And sometimes in ergonomics this is exactly what we will do.

Another strategy is to use anthropometry. For example an engineer is designing a work station used by many different people. Countless design decisions have to be made. How high, how wide, how big, how long, will it fit, etc.? Anthropometry can help. The word 'anthropometry' is derived from two Greek words:

- anthrōpos, (human being)
- metry (measuring)

### Size and Shape

Anthropometry is the study of the physical dimensions—size, shape and weight—of the human body. Anthropometric principles are applied across the full spectrum of the practice of ergonomics:

- Design standards
- Machine guards
- Reaches/heights
- Handle configuration
- General work station design
- Development of biomechanical models

### Data Tables

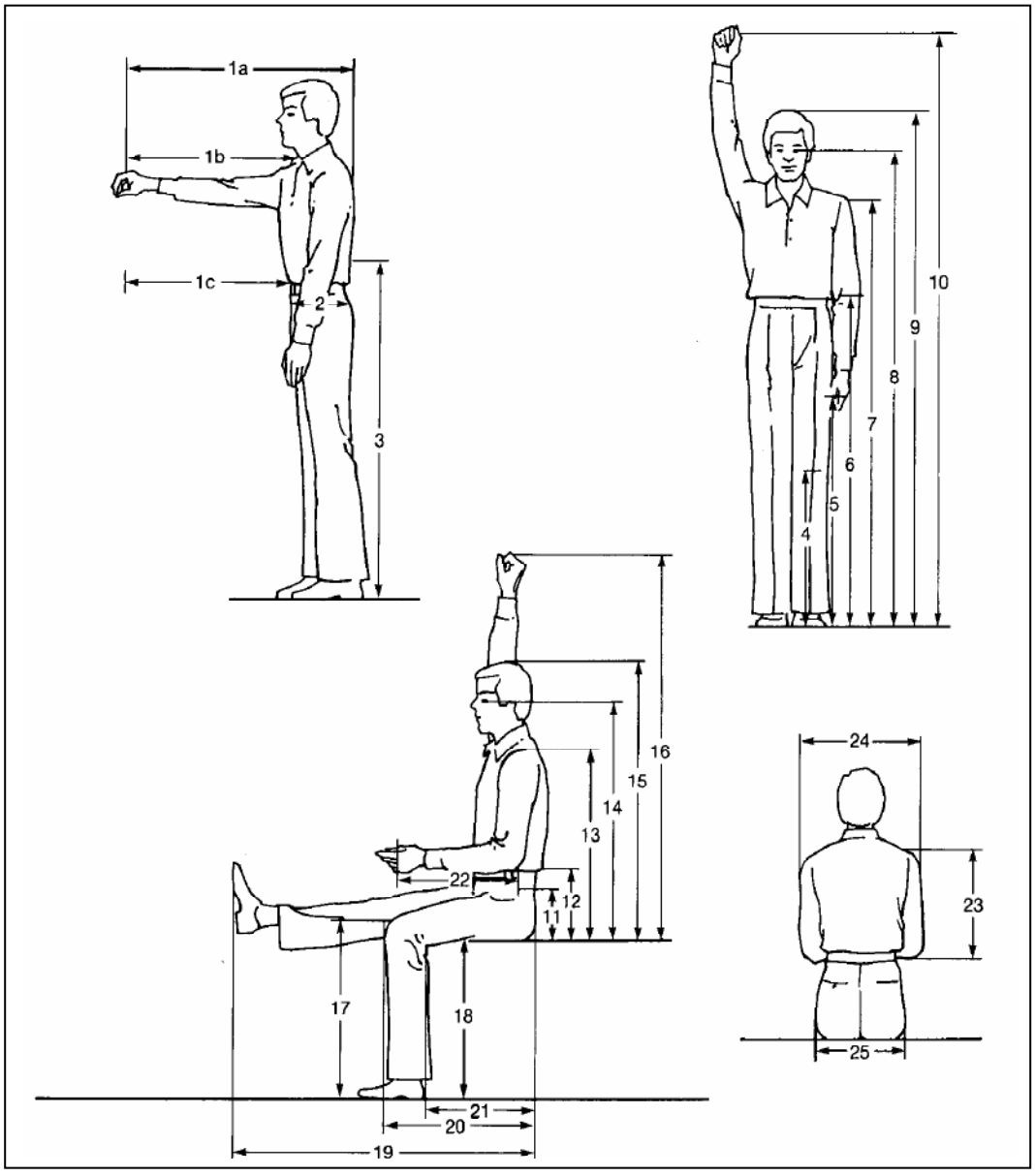
The basis for anthropometry is the careful measurement of the length, volume and weight of body part segments. From this, measurement tables have been generated that calculate a number of factors among others:

- Segment length
- Segment mass
- Center of mass location
- Inertial properties of the segment

The outcome is a set of statistical data that describes the human size and form. Often the data is described in terms of the mean and standard deviations. $5^{th}$, $50^{th}$ and $95^{th}$ percentiles are also calculated.

Examine the tables over the next pages to get a feel for what type of information is available.

# Anthropometry Data Table

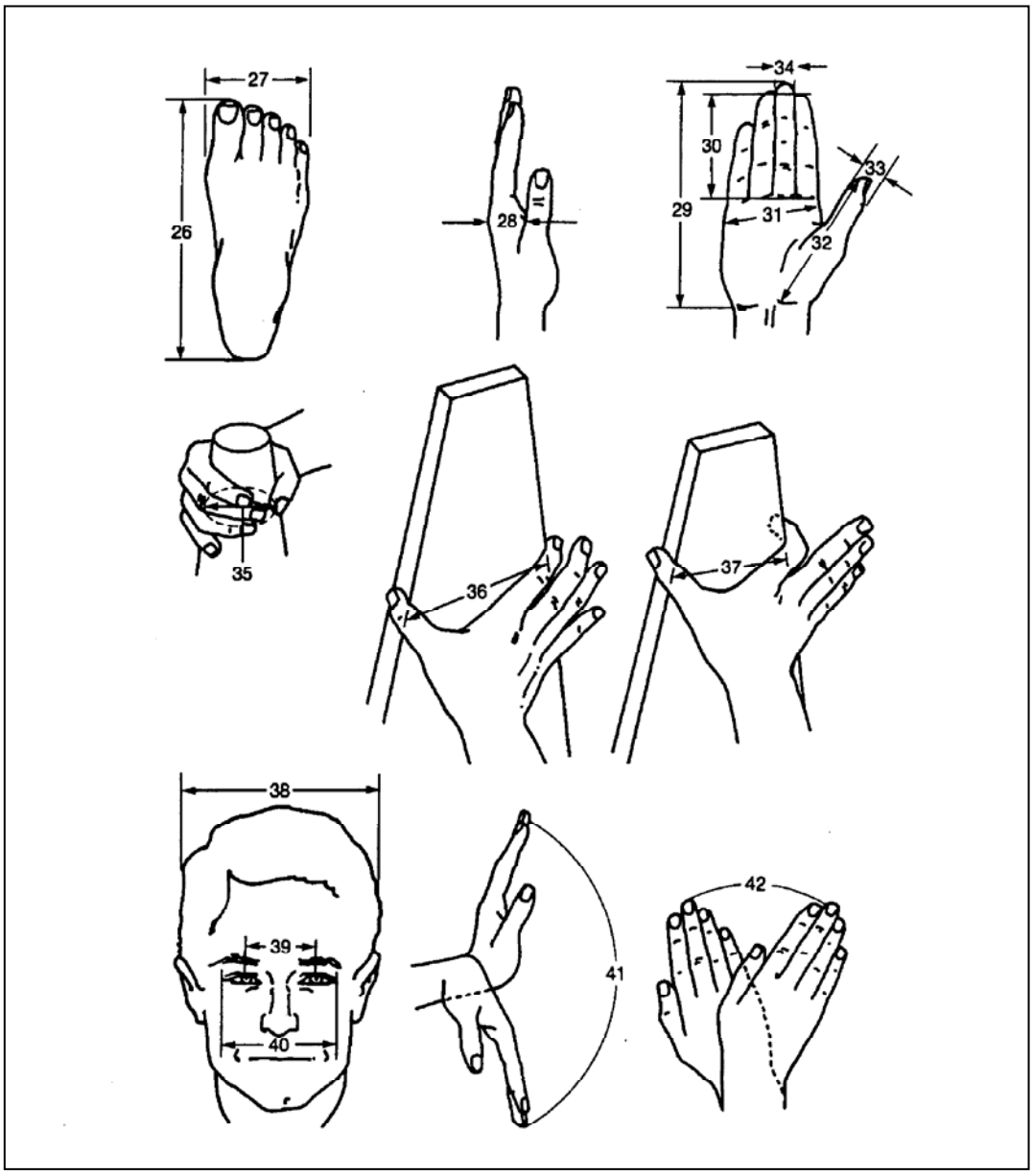


# Anthropometry Data Tables

Column 1 shows the measures and corresponding numbers from the body diagrams. Columns 2-7 provide the 5th, 50th and 95th percentiles respectively for males and females. Columns 8-10 show equivalent data for a 50/50 mix of males and females. All measures in inches. Data taken primarily from U.S. military personnel with sample size of several thousand.

| | Males | | | Females | | | 50/50 Males/Females | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5th | 50th | 95th | 5th | 50th | 95th | 5th | 50th | 95th |
| **STANDING** | | | | | | | | | |
| 1. Forward Functional Reach | | | | | | | | | |
| a. Includes body depth at shoulder | 28.7 | 32.5 | 36.3 | 26.2 | 29.2 | 32.2 | 27.2 | 30.7 | 35 |
| b. Acromial Process to Functional Pitch | 23.5 | 26.9 | 30.3 | 22.0 | 24.6 | 27.2 | 22.6 | 25.6 | 29.3 |
| c. Abdominal Extension to Functional Pitch | 17.4 | 24.4 | 31.4 | 18.6 | 23.8 | 29.0 | 19.1 | 24.1 | 29.3 |
| 2. Abdominal Extension Depth | 7.5 | 9.1 | 10.7 | 6.6 | 8.2 | 9.8 | 7.1 | 8.7 | 10.2 |
| 3. Waist Height | 37.7 | 41.9 | 46.1 | 36.0 | 40.0 | 44.0 | 37.4 | 40.9 | 44.7 |
| 4. Tibial Height | 15.7 | 17.9 | 20.1 | 14.7 | 16.5 | 18.3 | 15.3 | 17.2 | 19.4 |
| 5. Knuckle Height | 26.5 | 29.7 | 32.9 | 24.8 | 28.0 | 31.2 | 25.9 | 28.8 | 31.9 |
| 6. Elbow Height | 39.9 | 43.5 | 47.1 | 37.6 | 40.4 | 43.2 | 38.0 | 42.0 | 45.8 |
| 7. Shoulder Height | 51.8 | 56.6 | 61.4 | 46.5 | 51.9 | 57.3 | 48.4 | 54.4 | 59.7 |
| 8. Eye height | 59.9 | 64.7 | 69.5 | 55.2 | 59.6 | 64.0 | 56.8 | 62.1 | 67.8 |
| 9. Stature | 63.5 | 68.7 | 73.9 | 59.0 | 63.8 | 68.6 | 60.8 | 66.2 | 72 |
| 10. Functional Overhead Reach | 75.9 | 82.5 | 89.1 | 71.6 | 78.4 | 85.2 | 74.0 | 80.5 | 86.9 |
| **SEATED** | | | | | | | | | |
| 11. Thigh Clearance Height | 4.6 | 5.8 | 7.0 | 3.9 | 4.9 | 5.9 | 4.3 | 5.3 | 6.5 |
| 12. Elbow Rest Height | 6.9 | 9.5 | 12.1 | 6.7 | 9.1 | 11.5 | 7.3 | 9.3 | 11.4 |
| 13. Midshoulder Height | 22.1 | 24.5 | 26.9 | 20.8 | 22.8 | 24.8 | 21.4 | 23.6 | 26.1 |
| 14. Eye Height | 28.2 | 31.0 | 33.8 | 26.6 | 29.0 | 31.4 | 27.4 | 29.9 | 32.8 |
| 15. Sitting Height, Normal | 31.1 | 34.1 | 37.1 | 29.0 | 32.2 | 35.4 | 32.0 | 34.6 | 37.4 |
| 16. Functional Overhead Reach | 44.0 | 50.6 | 57.2 | 42.0 | 47.2 | 52.4 | 43.6 | 48.7 | 54.8 |
| 17. Knee Height | 19.1 | 21.3 | 23.5 | 18.1 | 20.1 | 22.1 | 18.7 | 20.7 | 22.7 |
| 18. Popliteal Height | 15.2 | 17.2 | 19.2 | 14.8 | 16.2 | 17.6 | 15.1 | 16.6 | 18.4 |
| 19. Leg Length | 37.6 | 41.4 | 45.2 | 36.2 | 39.6 | 43.0 | 37.3 | 40.5 | 43.9 |
| 20. Upper-Leg Length | 21.2 | 23.4 | 25.6 | 20.6 | 22.6 | 24.6 | 21.1 | 23.0 | 24.9 |
| 21. Buttocks-to-Popliteal Height | 17.2 | 19.2 | 21.2 | 16.5 | 18.9 | 21.3 | 17.2 | 19.1 | 20.9 |
| 22. Elbow-to-Popliteal Height | 12.4 | 14.2 | 16.0 | 10.5 | 12.7 | 14.9 | 12.6 | 14.5 | 16.2 |
| 23. Upper-Arm Length | 13.1 | 14.5 | 15.9 | 12.6 | 13.4 | 14.2 | 12.9 | 13.8 | 15.5 |
| 24. Shoulder Breadth | 16.3 | 17.9 | 19.5 | 13.8 | 15.4 | 17.0 | 14.3 | 16.7 | 18.8 |
| 25. Hip Breadth | 12.2 | 14.0 | 15.8 | 13.0 | 15.0 | 17.0 | 12.8 | 14.5 | 16.3 |

Data tables excerpted from: Human Factors Section, Eastman Kodak Company, *Ergonomic Design for People at Work*, Van Nostrand Reinhold, 1983.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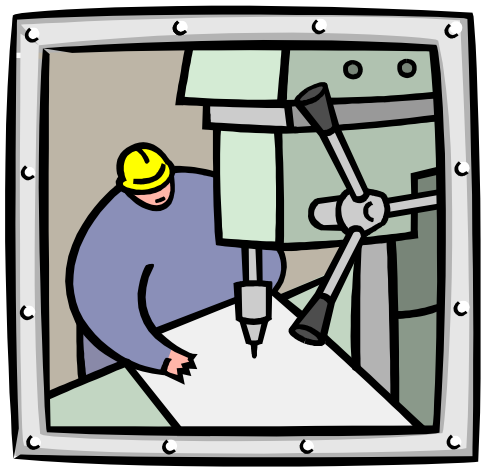
# Anthropometry Data Tables

| | Males | | | Females | | | 50/50 Males/Females | | |
|---|---|---|---|---|---|---|---|---|---|
| | 5th | 50th | 95th | 5th | 50th | 95th | 5th | 50th | 95th |
| **FOOT** | | | | | | | | | |
| 26. Foot Length | 9.5 | 10.5 | 11.5 | 8.7 | 9.5 | 10.3 | 8.9 | 10.0 | 11.2 |
| 27. Foot Breadth | 3.5 | 3.9 | 4.3 | 3.1 | 3.5 | 3.9 | 3.2 | 3.7 | 4.2 |
| **HAND** | | | | | | | | | |
| 28. Hand Thickness, Metacarpal III | 1.1 | 1.3 | 1.5 | 0.9 | 1.1 | 1.3 | 1.0 | 1.2 | 1.4 |
| 29. Hand Length | 6.7 | 7.5 | 8.3 | 6.4 | 7.2 | 8.0 | 6.7 | 7.4 | 8.0 |
| 30. Digit Two Length | 2.4 | 3.0 | 3.6 | 2.1 | 2.7 | 3.3 | 2.3 | 2.8 | 3.3 |
| 31. Hand Breadth | 3.0 | 3.4 | 3.8 | 2.6 | 3.0 | 3.4 | 2.8 | 3.2 | 3.6 |
| 32. Digit One Length | 4.2 | 5.0 | 5.8 | 3.6 | 4.4 | 5.2 | 3.8 | 4.7 | 5.6 |
| 33. Breadth of Digit One Interphalangeal Joint | 0.8 | 0.9 | 1.0 | 0.7 | 0.8 | 0.9 | 0.7 | 0.8 | 1.0 |
| 34. Breadth of Digit Three Interphalangeal Joint | 0.6 | 0.7 | 0.8 | 0.5 | 0.6 | 0.7 | 0.6 | 0.7 | 0.8 |
| 35. Grip Breadth, Inside Diameter | 1.5 | 1.9 | 2.3 | 1.5 | 1.7 | 1.9 | 1.5 | 1.8 | 2.2 |
| 36. Hand Spread, Digit One to Two, 1st Phalangeal Joint | 3.1 | 4.9 | 6.7 | 2.5 | 3.9 | 5.3 | 3.0 | 4.3 | 6.1 |
| 37. Hand Spread, Digit One to Two, 2nd Phalangeal Joint | 2.7 | 4.1 | 5.5 | 1.8 | 3.2 | 4.6 | 2.3 | 3.6 | 5.0 |
| **HEAD** | | | | | | | | | |
| 38. Head Breadth | 5.6 | 6.0 | 6.4 | 5.3 | 5.7 | 6.1 | 5.4 | 5.9 | 6.3 |
| 39. Interpupillary Breadth | 2.0 | 2.4 | 2.8 | 1.9 | 2.3 | 2.7 | 2.1 | 2.4 | 2.6 |
| 40. Biocular Breadth | 3.2 | 3.6 | 4.0 | 3.2 | 3.6 | 4.0 | 3.3 | 3.6 | 3.9 |
| **OTHER MEASUREMENTS** | | | | | | | | | |
| 41. Flexion-Extension, Range of Motion of Wrist Degrees | 96.0 | 134.0 | 172.0 | 111.0 | 141.0 | 171.0 | 108.0 | 138.0 | 166.0 |
| 42. Ulnar-Radial Range of Motion of Wrist Degrees | 34.0 | 60.0 | 86.0 | 39.0 | 67.0 | 95.0 | 41.0 | 63.0 | 87.0 |
| 43. Weight, in pounds | 117.0 | 183.4 | 249.8 | 84.9 | 146.3 | 207.7 | 105.3 | 164.1 | 226.8 |

**Note: All values may be affected by clothing and posture.**

Data tables excerpted from: Human Factors Section, Eastman Kodak Company, *Ergonomic Design for People at Work*, Van Nostrand Reinhold, 1983.

## Work station Height

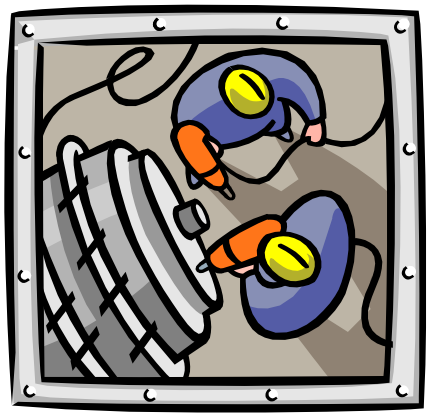


Returning to the engineer designing the work station, let's address the question of how high the work station should be. We could look for the tallest person and make sure the height accommodates that person. But, examining the tables we find that only a very few people are actually that height.

We could look for the average height individual in the data set. The 50th percentile height indicates half of the population is shorter and half is taller. But then this would accommodate only half of the population. The 95th percentile height would allow the taller person to fit. **Generally, it's considered easier to raise the shorter person to a higher level than lower the taller person.**

In practical use, we also have to consider the type of work being performed - hand work, precision or forceful - as well as the size and shape of the material.

## Work station Reach



Let's examine the other end of the continuum. A work station is being designed including the layout of parts and materials. How far away, at maximum, should the supplies be placed and still achieve a reasonable reach?

In a fixed work station design we need to look at the reach envelope of the smallest individual. The adopted convention is to design for the 5th percentile woman.

In reality the best bet is to build in reach flexibility to accommodate both ends of the reach envelope. A 95th percentile man feels quite cramped at the 5th percentile woman's reach.

So, by applying the principles of anthropometry as part of the overall systems design, objectives of enhancing human performance by controlling fatigue can be met.

## Anthropometry Principles

1. Design to allow the tall person to fit
2. Design to allow the short person to reach

# Control Manual Material Handling

## *How Much Can a Person Lift?*

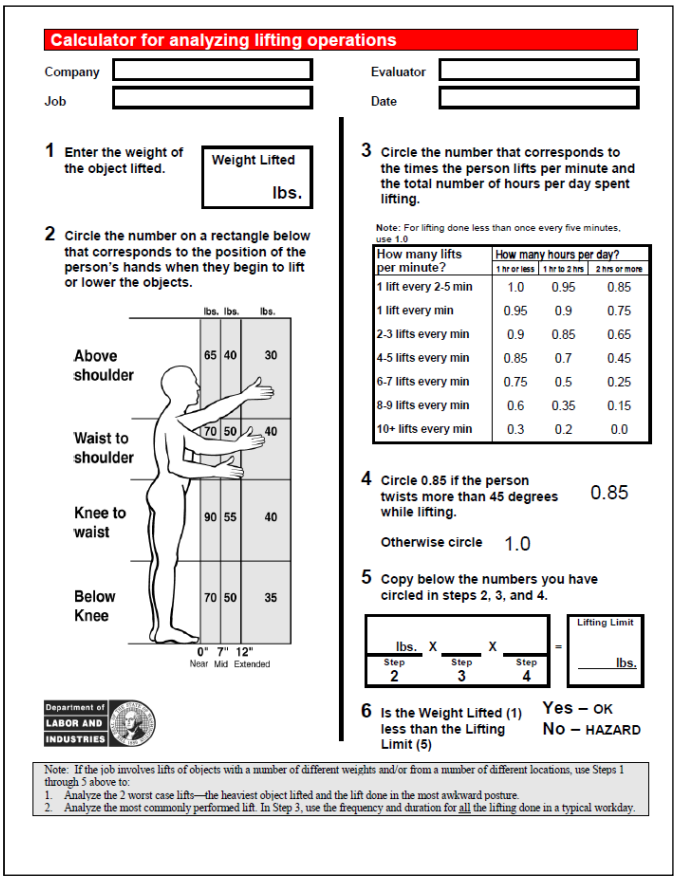
The next ergonomics principle details the specifics regarding manual material handling capabilities of individuals.

How much can a person lift in a safe and effective way? What are the factors involving the manual handling that need to be considered? These questions have been studied extensively over the past 30 years.

## *Lifting Calculator (State of Washington Department of Labor and Industries)*

A simplified version of the NIOSH Work Practices Guide for Manual Lifting was developed by the State of Washington Department of Labor and Industries.

It is easy to use and provides valuable information.



**Calculator for analyzing lifting operations**

Company _____ Evaluator _____

Job _____ Date _____

**1** Enter the weight of the object lifted. Weight Lifted ____ lbs.

**2** Circle the number on a rectangle below that corresponds to the position of the person's hands when they begin to lift or lower the objects.

| | lbs. | lbs. | lbs. |
|---|---|---|---|
| Above shoulder | 65 | 40 | 30 |
| Waist to shoulder | 70 | 50 | 40 |
| Knee to waist | 90 | 55 | 40 |
| Below Knee | 70 | 50 | 35 |

0" 7" 12"
Near Mid Extended

Department of LABOR AND INDUSTRIES

**3** Circle the number that corresponds to the times the person lifts per minute and the total number of hours per day spent lifting.

Note: For lifting done less than once every five minutes, use 1.0

| How many lifts per minute? | How many hours per day? 1 hr or less | 1 hr to 2 hrs | 2 hrs or more |
|---|---|---|---|
| 1 lift every 2-5 min | 1.0 | 0.95 | 0.85 |
| 1 lift every min | 0.95 | 0.9 | 0.75 |
| 2-3 lifts every min | 0.9 | 0.85 | 0.65 |
| 4-5 lifts every min | 0.85 | 0.7 | 0.45 |
| 6-7 lifts every min | 0.75 | 0.5 | 0.25 |
| 8-9 lifts every min | 0.6 | 0.35 | 0.15 |
| 10+ lifts every min | 0.3 | 0.2 | 0.0 |

**4** Circle 0.85 if the person twists more than 45 degrees while lifting. 0.85

Otherwise circle 1.0

**5** Copy below the numbers you have circled in steps 2, 3, and 4.

lbs. (Step 2) X ____ (Step 3) X ____ (Step 4) = Lifting Limit ____ lbs.

**6** Is the Weight Lifted (1) less than the Lifting Limit (5) Yes – OK / No – HAZARD

Note: If the job involves lifts of objects with a number of different weights and/or from a number of different locations, use Steps 1 through 5 above to:
1. Analyze the 2 worst case lifts—the heaviest object lifted and the lift done in the most awkward posture.
2. Analyze the most commonly performed lift. In Step 3, use the frequency and duration for all the lifting done in a typical workday.

## *Manual Material Handling Checklist*

Refer to the ***Addendum - Work Force, Work Station and Work Process*** at the end of the manual for additional specific information to reduce the risk of manual material handling..

Use the ***Manual Material Handling Checklist*** as needed for the ergonomics analysis process.

# Manual Material Handling Checklist

**"NO" response indicates potential problem area that should receive further investigation.**

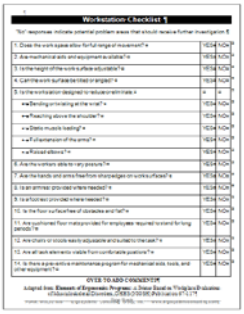
| | | | |
|---|---|---|---|
| 1. Are the weights of loads to be lifted judged acceptable by the workforce? | YES | NO | NA |
| 2. Are materials moved over minimum distances? | YES | NO | NA |
| 3. Is the distance between the object load and the body minimized? | YES | NO | NA |
| 4. Are walking surfaces: | | | |
| • Level? | YES | NO | NA |
| • Wide enough? | YES | NO | NA |
| • Clean and dry? | YES | NO | NA |
| 5. Are objects: | | | |
| • Easy to grasp? | YES | NO | NA |
| • Stable? | YES | NO | NA |
| • Able to be held without slipping? | YES | NO | NA |
| 6. Are there handholds on objects? | YES | NO | NA |
| 7. When required, do gloves fit properly? | YES | NO | NA |
| 8. Is the proper footwear worn? | YES | NO | NA |
| 9. Is there enough room to maneuver? | YES | NO | NA |
| 10. Are mechanical handling aids (powered or manual) used whenever possible? | YES | NO | NA |
| 11. Are working surfaces adjustable to the best handling heights? | YES | NO | NA |
| 12. Does material handling avoid: | | | |
| • Movements below knuckle height and above shoulder height? | YES | NO | NA |
| • Static muscle loading? | YES | NO | NA |
| • Sudden movements during handling? | YES | NO | NA |
| • Twisting at the waist? | YES | NO | NA |
| • Extended reaching? | YES | NO | NA |
| 13. Is help available for heavy or awkward lifts? | YES | NO | NA |
| 14. Are high rates of repetition avoided by: | | | |
| • Job rotation? | YES | NO | NA |
| • Self-pacing? | YES | NO | NA |
| • Sufficient pauses? | YES | NO | NA |
| 15. Are pushing or pulling forces reduced or eliminated? | YES | NO | NA |
| 16. Does the employee have an unobstructed view of handling the task? | YES | NO | NA |
| 17. Is there a preventive maintenance program for equipment? | YES | NO | NA |
| 18. Are workers trained in correct handling and lifting procedures? | YES | NO | NA |

## Provide Correct Workstations, Tools and Equipment

Providing the correct tools, equipment and facilities is a critical ergonomics principle. Safer, faster and more productive are the tangible results.

The correct workstation, tools and equipment can make the difference between getting the job done or not at all. And even worse, the wrong tool can result an injury to the use.

### *Work Station*

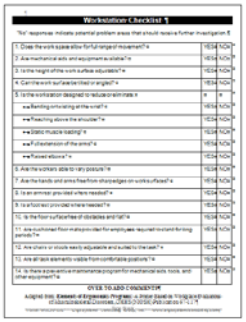


The general design and set-up of the work station is an important factor. We will examine a number of factors to adequately assess the work station.

Refer to the ***Addendum - Work Force, Work Station and Work Process*** at the end of the manual for additional details.

Use the ***Workstation Checklist*** as needed for the ergonomics analysis process.

### *Tools*



How much money do professional carpenters spend on tools?

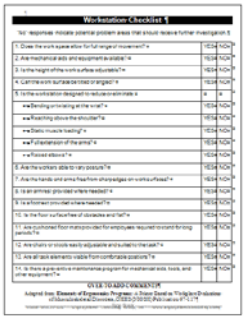
In fact they may have one tool that does just one job!

Why is it worth the investment? That specific tool makes the job go faster and easier with less chance of injury.

Refer to the ***Addendum - Work Force, Work Station and Work Process*** at the end of the manual for additional details.

Refer to the ***Tool Checklist*** for additional information.

### *Equipment*



Part of the work station is the machinery/equipment used in the operation. Look for a number of factors including foot pedals, hand controls, whole body vibration, maintenance, etc.

Refer to the ***Addendum - Work Force, Work Station and Work Process*** at the end of the manual for additional details.

Refer to the ***Equipment Checklist*** for additional information.

# Workstation Checklist

**"NO" response indicates potential problem areas that should receive further investigation.**

| | | | |
|---|---|---|---|
| 1. Does the work space allow for full range of movement within the workstation? | YES | NO | NA |
| 2. Is the height of the work surface adjustable? | YES | NO | NA |
| 3. Can the work surface be tilted or angled to provide a comfortable view of the job being done? | YES | NO | NA |
| 4. Is the workstation designed to reduce or eliminate: | | | |
| • Bending or twisting at the wrist? | YES | NO | NA |
| • Reaching above the shoulder? | YES | NO | NA |
| • Static muscle loading? | YES | NO | NA |
| • Full extension of the arms? | YES | NO | NA |
| • Raised elbows? | YES | NO | NA |
| 5. Are the workers able to vary posture? | YES | NO | NA |
| 6. Are the hands and arms free from sharp edges on work surfaces? | YES | NO | NA |
| 7. Is an armrest provided where needed? | YES | NO | NA |
| 8. Is a footrest provided where needed? | YES | NO | NA |
| 9. Is the floor surface free of obstacles and flat? | YES | NO | NA |
| 10. Are cushioned floor mats provided for employees required to stand for long periods? | YES | NO | NA |
| 11. If a chair/stool is provided, is its design and adjustability satisfactory and suited to the task? (Back support, vertical adjustability, etc.) | YES | NO | NA |
| 12. Are all task elements visible from comfortable positions (seated or standing)? | YES | NO | NA |
| 13. Is there a preventive maintenance program for mechanical aids, tools, and other equipment? | YES | NO | NA |
| 14. Is the worker able to work within the comfort and functional reach zones? | YES | NO | NA |
| 15. Is it possible for the worker to alternate sitting and standing when performing the task? | YES | NO | NA |
| 16. Is there adequate space at the workstation to perform the work effectively and comfortably? | YES | NO | NA |
| 17. Can position of tools/equipment and controls be adjusted to suit the worker? | YES | NO | NA |
| 18. If parts and materials containers/bins/tubs/carts are used, are they conveniently placed? | YES | NO | NA |
| 19. Are mechanical aids and mechanical handling equipment available? | YES | NO | NA |
| 20. Is the workstation accessible to material handling equipment? | YES | NO | NA |
| 21. Is clearance space in the workplace adequate for maintenance tasks? | YES | NO | NA |
| 22. | | | |

# Tool Checklist

**"NO" response indicates potential problem areas that should receive further investigation.**

| | | | |
|---|---|---|---|
| 1. Are power tools used and acceptable? *(If not acceptable what problems with power tools are noted?)* | YES | NO | NA |
| 2. Are manual tools used and acceptable? *(If not acceptable what problems with power tools are noted?)* | YES | NO | NA |
| 3. Are tools selected to limit or minimize: | | | |
| • Exposure to excessive vibration? | YES | NO | NA |
| • Use of excessive force? | YES | NO | NA |
| • Bending or twisting the wrist? | YES | NO | NA |
| • Finger pinch grip? | YES | NO | NA |
| • Problems associated with trigger finger? | YES | NO | NA |
| 4. Are tools powered where necessary and feasible? | YES | NO | NA |
| 5. Are tools evenly balanced? | YES | NO | NA |
| 6. Are heavy tools suspended or counterbalanced in ways to facilitate use? | YES | NO | NA |
| 7. Does the tool allow adequate visibility of the work? | YES | NO | NA |
| 8. Does the tool grip/handle prevent slipping during use? | YES | NO | NA |
| 9. Are tools equipped with handles of textured, non-conductive material? | YES | NO | NA |
| 10. Are different handle sizes available to fit a wide range of hand sizes? | YES | NO | NA |
| 11. Is the tool handle designed not to dig into the palm of the hand? | YES | NO | NA |
| 12. Can the tool be used safely with gloves? | YES | NO | NA |
| 13. Can the tool be used by either hand? | YES | NO | NA |
| 14. Is there a preventive maintenance program to keep tools operating as designed? | YES | NO | NA |
| 15. Have employees been trained: | | | |
| • In the proper use of tools? | YES | NO | NA |
| • When and how to report problems with tools? | YES | NO | NA |
| • In proper tool maintenance? | YES | NO | NA |

# Equipment Checklist

**"YES" response indicates potential problem areas that should receive further investigation.**

| | | | |
|---|---|---|---|
| **Foot/knee control pedals** | | | |
| 1. Does the operator have to operate foot/knee pedals while standing? | YES | NO | NA |
| 2. To operate foot pedals or knee switches, must the worker assume an unnatural or uncomfortable posture? | YES | NO | NA |
| 3. Are pedals too small to allow the operator to alter the position of the foot/knee? | YES | NO | NA |
| 4. Are pedals triggered at a high repetition rate? | YES | NO | NA |
| **Hand controls** | | | |
| 5. Hand controls placed to **not** allow neutral hand/arm/body position? | YES | NO | NA |
| 6. Hand controls difficult (require excessive force) to operate? | YES | NO | NA |
| 7. Hand controls not properly designed to take into account amount and types of force required for operation? | YES | NO | NA |
| 8. Do workers have to exert high levels of power grip force to operate equipment? | YES | NO | NA |
| 9. Do workers have to exert high levels of pinch grip force to operate equipment? | YES | NO | NA |
| **Position - Sustained/Awkward** | | | |
| 10. To operate equipment, must worker maintain same body posture (either sitting or standing) all or most of the time? | YES | NO | NA |
| 11. Is the pace of material handling determined by the equipment? (Feeding machines, conveyors, etc.) | YES | NO | NA |
| 12. Does equipment operation require worker to repeat same movement pattern of arm/hand at a high rate of speed? | YES | NO | NA |
| 13. Does equipment operation require continuous use (or nearly so) of both hands and both feet in order to operate controls or manipulate work object? | YES | NO | NA |
| **Vibration - Whole body** | | | |
| 14. Is the body as a whole subjected to vibration from exposure to or operation of the equipment? | YES | NO | NA |
| **Equipment Preventive Maintenance** | | | |
| 15. Is there **not** a regular maintenance schedule? | YES | NO | NA |
| 16. Is the equipment designed or placed in such a way that cleaning and maintenance activities are **not** facilitated? | YES | NO | NA |

## Provide Competency Based Training

**This ergonomics principle indicates that adequate workforce training is a critical part of the ergonomics process.**

### *Results not Achieved?*

A company spends thousands of dollars on tools, equipment and facility that are ergonomically designed but they don't achieve the desired results. What happened?

In many situations the problem is that the workforce doesn't know how to make the most of the tool or equipment or furniture. Two sides of the coin emerge: you need to have the correct item AND you need to know how to use it properly. For the workforce to really get the benefits of ergonomics they need to be able to demonstrate competency in the setup and use of the tool or equipment.

To give you an example. A company purchased new fully featured ergonomics office chairs. They were delivered and put into use. A short while later during an ergonomics audit it was determined that no one had adjusted the chairs for their specific needs. They hadn't received any instruction in how to use the chairs - they just sat down and went to work. In fact a number of individuals reported they actually felt intimidated by the chair and all of its "bells and whistles"!

*If you want to improve your golf game (or some other physical skill) what do you need to do? Right, you need to correctly practice the new technique to acquire the skill level to advance.*

*In the same way, ergonomics is all about learning new skills; provide training sessions that involve a hands-on approach. Over time, with proper feedback and practice, the desired result will be accomplished.*

## Control Exposure to Work Environment

Controlling exposure to the work environment includes light, noise, temperature and ventilation is the next principle.

*(What do you think, can we set the thermostat at a level that everyone will agree to? The goal is to shoot for the middle and let individuals use personal controls based on their needs.)*

Refer to the ***Addendum - Work Force, Work Station and Work Process*** at the end of the manual for additional details.

Use the ***Environment Checklist*** as needed for the ergonomics analysis process.

# Environment Checklist

**"YES" response indicates potential problem area that should receive further investigation.**

| | | | |
|---|---|---|---|
| **Illumination** | | | |
| **1.** Is special lighting necessary to perform the job? | YES | NO | NA |
| **2.** Is the general work area including egress/ingress poorly lit? | YES | NO | NA |
| **3.** Is lighting inadequate for the job tasks? | YES | NO | NA |
| **4.** Are controls, instruments and equipment poorly lit? | YES | NO | NA |
| **5.** Is the illumination not satisfactory for task? | YES | NO | NA |
| **6.** Is contrast poor between workspace and surroundings? | YES | NO | NA |
| **7.** Is workplace so poorly lit that there are great differences between brightness levels in panels, dials and surroundings? | YES | NO | NA |
| **8.** Is glare present in workplace? (What is source of the glare?) | YES | NO | NA |
| **9.** Is glare from displays a problem? | YES | NO | NA |
| **Auditory/Noise** | | | |
| **10.** Does the noise exposure require a hearing conversation program? | YES | NO | NA |
| **11.** Does noise level prevent or impair verbal communication? | YES | NO | NA |
| **12.** Are there auditory signals? | YES | NO | NA |
| **13.** Are some auditory signals hard to hear in general? | YES | NO | NA |
| **Air (Temperature, Quality, Flow, Humidity)** | | | |
| **14.** Is the air temperature too cold? | YES | NO | NA |
| **15.** Is the air temperature too hot? | YES | NO | NA |
| **16.** Is it too humid in workplace? | YES | NO | NA |
| **17.** Are radiant heat sources placed near any workstations? | YES | NO | NA |
| **18.** Are there rapid changes in temperature in work environment? | YES | NO | NA |
| **19.** Is there so much air contaminant in the process that it settles on displays, making them difficult to see? | YES | NO | NA |
| **20.** Are suspended dust, mists and other particulates present in the air? | YES | NO | NA |
| **21.** Is air circulation too low? | YES | NO | NA |
| **22.** Is there too much air movement? | YES | NO | NA |
| **23.** Are workers exposed to rapid environmental changes? | YES | NO | NA |
| **24.** Is the humidity frequently uncomfortable enough to interfere with the job? | YES | NO | NA |
| **25.** Are there wet locations that may produce shock hazards for work with electrically powered equipment? | YES | NO | NA |

## Promote Health and Wellness!

What is the most important tool we all own?

This principle directly addresses our need to maintain the most important tool we have . . . our minds and our bodies; in other words our physical and mental health.

The goal is to provide a workplace where regular health and wellness concepts and practices are built into the course of doing business. Health and wellness factors include:

- Diet and nutrition
- Body weight control
- Stress management
- Smoking cessation
- Blood pressure control
- Fluid intake - don't get dehydrated
- Adequate rest/sleep

For example: movement helps to control fatigue by relieving awkward and sustained positions and promoting circulation to the body's tissues.

*Who has dogs or cats at home? When they first get up from a little nap what is the first thing they do? We have an instinctive need to move . . . we just need to pay attention to it.*

## Provide On-going Feedback and Follow-up

The last ergonomics principle is to provide on-going feedback and follow-up regarding the ergonomics analyses and processes.

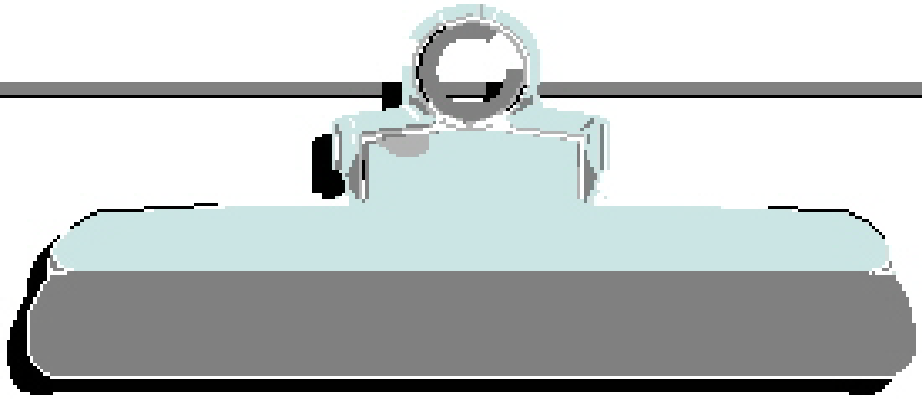
### *100% Correct the First Time?*

In your experience does any new process work 100% correctly out of the gate? Even with the best up-front planning there will be unintended consequences, something will vary from the plan. This is why providing on-going feedback as part of the follow-up process is so critical.

Schedule formal follow-up sessions at regularly intervals; for example one week post-implementation and then one month, six months and one year. Document the outcome of the follow-up, very importantly alleviate the issues identified in a timely manner and publicize the lessons learned.

### *Continuous Process Improvement and Ergonomics*

Applying ergonomics principles to the overall continuous process improvement effort is integral to the success of the process. Recalling that ergonomics is focused on optimizing performance (enhancing safety and quality and productivity) is made stronger when on-going feedback and follow-up is performed.



# Ergonomics Principles

**PROCESS** – Promote effective work processes

**POSITION/SUPPORT** – Promote neutral body and limb position/support

**MOVEMENT** – Promote regular physical movement

**MATERIAL HANDLING** – Control manual material handling

**REACH** – Promote work in reach zone

**WORKSTATION/TOOLS/EQUIPMENT** – Provide correct workstation, tools and equipment

**TRAINING** – Provide competency based training

**ENVIRONMENT** – Control exposure to work environment

**HEALTH/WELLNESS** – Promote personal health and wellness

**FEEDBACK** – Provide on-going feedback for continuous improvement

## ERGONOMICS PROBLEM SOLVING PRINCIPLES

**If you like to solve problems, ergonomics is for you!**

Identifying and solving problems is at the core of the ergonomics process. Here are a few important caveats to problem solving.

## Caveats

### *Design dictates performance*

Recall the toolbox on the floor scenario. Placing a toolbox on a floor promotes poor technique to remove the tools. Body mechanics training may be ineffective in promoting proper technique. The successful response involves repositioning the toolbox to waist height to promote the desired technique. You can apply this concept in any workplace for any ergonomics problem.

### *Understand and make productive use of human behavior*

The study of human behavior is a most fascinating and frustrating field of study. There are reasons why we do what we do; sometimes we just can not figure out what they are! It is possible, however, to understand human behavior at some level, and to use this knowledge in a productive way. If we offer a solution that is contrary to the nature of human behavior, the solution will not be effective.

### *Do not fix without adequate analysis!*

Many novice analysts (and sometimes some experienced ones) cause themselves and others problems because they try to "fix stuff" without knowing why or what or when or who. Perform an adequate analysis before offering recommendations.

### *Always ask why!*

Sometimes when we look at work, all we see is what is in front of us. It is imperative that we look both up and down stream to see the context of a single work station or job demand within the overall production scheme.

### *Don't generalize from a sample of one!*

A common error made is to make the assumption that just because it makes sense to mo or works for a particular individual it will also work for the entire population. Be careful not to fall into the trap of population stereotypes. Recognize the diversity that exists in the user population and design to take this into account.

### *Scope of Influence*

Know the scope of influence of the situation and the worker and not exceed the worker's scope of influence. If we offer a solution that is beyond the scope of influence of the individual, department, or organization, the solution will not work.

### *Overcome resistance to change*

Most people do not like change. If we try to introduce change we have to do it in a very careful way, otherwise the solution will not work. How is change accomplished?

Creating positive change

Creating positive change is truly the core of any successful ergonomics process. Work through this exercise. Pull from your own experiences with change.

| Why do people resist change? | How to facilitate change! |
|---|---|
| | |
| 1. | |
| 2. | |
| 3. | |
| 4. | |

Why to do people resist change?

- They fear of change.
- They do not recognize the need for change.
- They do not know how to accomplish change.
- The change is forced on them.
- Was not their idea!
- Habit!
- No one else is changing!

How to facilitate positive change?

- Show opportunity exists to change
- Show how to accomplish change
- Show what happens if you do change
- Show what happens if you do not change (hopefully this does not have to happen to elicit change)

## Ergonomics Analysis Tool Box

Your job performance analysis toolbox will have several trays.

### *Personal Protective Equipment*

Ensure that you have the proper personal protective equipment and attire to conduct the analysis. At a minimum, you may need eye, foot, clothing, head, and hearing protection.

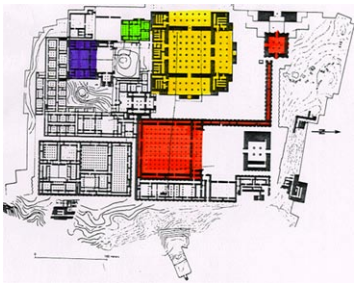
Dress at the proper level based on the worker's level of attire. For example, do not show up in a suit, white shirt, and tie on an assembly production floor, just as jeans, steel toe boots, and a work shirt may not be appropriate for a boardroom.

### *Measurement Devices*

To take measurements of the workplace, you'll need a stopwatch, tape measure, force gauge, and photographic equipment (video camera, 35-mm camera, etc.)

**A NOTE OF CAUTION: <u>always</u> have prior authorization to bring any photographic or videographic equipment on premises, and know how to handle sensitive proprietary data.**

### *Background Materials*



Identify the proper background materials to have available. This could include job descriptions, sketch of the floor plan or layout, organizational chart, check lists, clipboard or notepad, Dictaphone, etc.

### *Set of Objectives*

The most important tray in your toolbox is the set of objectives you bring to the job.

- What are the outcome objectives?
- Make sure you bring an "open mind."
- Do not hesitate to ask questions.

The most important thing you bring to the work place is a new and fresh look at the situation. What has become common place to those in the workplace may be brand new to you. Take advantage of this opportunity.

## Why Videotape?

If a picture is worth 1,000 words, a moving picture (video) must be worth at least 5,000 words.

Using videotape is one of the best ways to document a Job Performance Analysis.

- You can study the videotape over and over again at a later date.
- With a reasonable four head VCR, you can play the tape in slow motion and stop action.
- You can show the tape to other interested parties for their input.

### *Videotaping "Secrets"*

Because you don't want to be accused of making home videotapes, follow these guidelines.

- Use enough light. Low light causes grainy videotape that is hard to analyze.
- Plan your videotaping sequence. Think ahead to know what shots you want.
- Use a tripod as much as you can. You will get much better quality tape.
- If you have to use a handheld technique, build a bridge with your arm against your body for stability.
- Use the zoom sparingly. Zooming in and out in and out will drive your audience wild.
- Tape no more than 20 to 30 minutes per tape. Searching through 120 minutes of tape to find your scene will drive you wild.
- Always have a backup power supply; either additional battery packs or is able to run off of wall current with the AC adapter.
- After videotaping a few seconds, check to make sure the camcorder is

working correctly. Blank tape is very embarrassing!

- Use manual focus (if available) to stop the auto focus from searching.
- Pan (move from side to side) the camera about three times more slowly than what your eye can track.
- In a loud environment, use a separate microphone to pick up interviews.
- Be aware of your surroundings; don't walk into equipment, people, etc.

### *Videotaping Sequence*

- Document the name of the job with a brief description
- Inform any people being videotaped of your purposes.
- Record the date and time
- Say the name of the job or task description on the audio portion of the tape at the beginning of each task.
- In the viewfinder, frame an overview of the job to "set the stage."
- Capture 5 to 6 cycles of repetitive tasks.
- Videotape as many different workers as you need to get an accurate portrayal of the job.
- Reposition the camera to get back, side and diagonal views. If possible, get an overhead view.
- Get close up views of each of the separate job tasks and identified issues
- If needed video the tasks immediately before and after the task being reviewed-this may also lend additional insight.

## ERGONOMICS FIELD STUDY

### Perform Ergonomics Analysis

You will be asked to perform an actual ergonomics analysis and present your findings to the class. Please read the following pages to familiarize yourself with this assignment. You will be given approximately 15 to 20 minutes for your ergonomics presentations, so keep the scope of your analysis very focused.

Effective problem solving is a skill set like any other. Initially, a discrete series of follow-along-steps will help to guide the process. Later, with gained expertise, a more holistic approach can be adapted.

### Ergonomics Analysis Process

Please refer to the **Ergonomics Analysis Worksheet** to conduct the analysis. Here are details specific to the five-step Ergonomics Analysis Process.

#### *Step 1: Gather and document BACKGROUND INFORMATION.*

Fill in the background information:

- Job/Task
- Area/Dept.
- Date
- Time
- Analyzed by
- Name (optional)

#### *Step 2: Describe the job/task and outline CURRENT MAJOR STEPS to complete the job/task.*

Interview the person or persons performing the job to gain their insight and perspective. *(Involve all people who can provide input; you absolutely have to involve the operator/worker. After all, who is the very best ergonomist?)*

Observe the job. If it makes sense try the job yourself. Once you have a handle on the job, briefly describe the job/task as concisely as you can. Answer the basics questions of:

- Who?
- What?
- Why?
- When?
- Where?
- How much?
- How long?
- By whom?

Document the present steps to complete the task. Identify the performance

measures and goals. Make a list of all of the tools, equipment and facilities required to perform the job. Use a flow chart or checklist or some other approach you have found to work for you.

**Comments**

- Compare experienced faster and injury-free workers with those who are inexperienced, fatigued, uncomfortable, or complaining of pain or injury.
- Determine if there are differences in work technique among these groups.
- If repetitive, note cycle time, capture a minimum of 5 cycles.
- Sketch the work area, if needed.
- Obtain weights and measures as needed.

### *Step 3: Compare present job/task steps to Ergonomics Principles/Reference Standard to identify ERGONOMICS ISSUES.*

Compare the present method to the principles/guidelines.

- Identify the performance gaps between the actual method and the desired method.
- Document the performance gaps.

Remember to always ask why a particular task is being done in a particular way. Is there a better way?

### *Step 4: Develop, justify and implement realistic and feasible SOLUTIONS.*

#### Develop solutions

Brainstorm on specific interventions.

- Be careful you don't recommend wholesale change.
- A "minimalist" approach may be much more palatable.

#### Perform Cost Analysis

In this day of downsizing and budget cuts it's easy for any organization to be penny wise and pound foolish. We all know that management is under a great deal of pressure to cut costs and save money where ever possible.

We also know that many jobs and tasks we perform are not designed safely or efficiently and must be improved. We must be able to justify our requests for ergonomic improvements in terms that management can understand. That's right - dollars and cents.

Here is a simple formula that can be used to decide how to intervene. It is useful to justify the ergonomics intervention either when significant resources are involved or when little or no resources are required. This formula will help prioritize your ergonomics project list.

#### ROI = Total Estimated Benefit/Total Cost of Intervention

Return of investment (ROI) is the primary calculation in this formula. It requires

the following information.

*Costs of Intervention:*

- Material/Hardware Costs
- Labor cost for installation
- Training costs
- Any other cost related to the intervention

*Benefits of Intervention:*

- Reduced labor costs
- Productivity gains
- Lower injury/illness costs

*Indirect Benefits:*

- Quality improvements
- Reduced scrap/rework
- Improved morale
- Improved idea sharing and problem solving
- Improved team work/owner-ship
- Reduced absenteeism

For the inexpensive fixes you don't need to spend a great deal of time gathering data and calculating your ROI. For more expensive and important projects this time will be well worth it. Even the most reluctant manager will make the right decision when the ROI is high and the payback period is relatively short.

### Implement Solutions

The goal is to accomplish controlled measurable change. If you change too many variables all at once you run the risk of not being able to recognize what did and did not work. Apply the principles but be careful of generalizations. In all likelihood, the "normal" person does not exist.

The modification itself is not the issue; the acceptance and integration of the modification is the issue. Introducing the job modification into the work place only begins the process.

### *Step 5: FOLLOW-UP: evaluate outcome and make needed changes.*

Proper outcomes evaluation continues the process. On-going measures are compared to the initial performance measures.

- Compare at set intervals (1, 3, 9, and 12-month intervals).
- Determine changes in performance measures
- Detail lessons learned to modify the interventions.
- Reevaluate and repeat the analysis steps.

## ADDENDUM - WORK FORCE, WORK STATION AND WORK PROCESS

### Components of Ergonomics

Recall ergonomics is all about optimizing performance. How many factors influence performance? In two minutes how many can you list?

1. _____ 2. _____ 3. _____
4. _____ 5. _____ 6. _____
7. _____ 8. _____ 9. _____
10. _____ 11. _____ 12. _____

### Three primary components

Many factors make up the equation of a workplace that is safe, healthy and productive. We categorize them into three primary components:

- **Work Force**
- **Work Station**
- **Work Process**

In this section we will examine each component in more detail. The factors we identify build on the foundation principles. It is important to recognize that the factors within each of the components are often inter-related and that the components themselves overlap.

### Work Force

The ***Work Force*** is a critical component. The essence of ergonomics focuses on enhancing the health, safety and productivity of the work force.

As part of the Job Performance Analysis process we will closely examine a number of factors.

#### *Work Force Demographics*

When ergonomics is used at the organizational level, it is to develop a description of the individual worker and/or workforce: age, fitness level, training and experience levels, gender breakdown, body stature, hand dominance and so on.

Ergonomics findings and recommendations are greatly influenced by these factors.

### Age

Physiological changes occur as a matter of aging:

- Strength and flexibility may significantly decrease.
- Aerobic capacity and endurance decrease.
- Visual acuity may deteriorate.
- Reflexes and hand-eye coordination may deteriorate.

Changes also take place in psychosocial aspects. With age, work experience associated with work expertise is enhanced. Experienced workers bring a valuable factor to the workplace.

### Gender

Knowledge of the gender breakdown is often required to implement successful ergonomics interventions. This is important to know in terms of proper:

- Fit and use of work stations, tools, equipment and clothing. For example small hand size vs. large hand size in relation to tool handle size.
- Match between physical demands of the job and functional capacity levels of the worker.

### Stature and Morphology

Anthropometry - the study of the size and shape of the body plays an important role. Assessing the stature and morphology numerical ranges of the workforce is necessary to provide for adequate design and use of the workplace.

- In other words . . . How tall? How short? How big? How small?

### Hand Dominance

Approximately 90% of the general population is right-hand dominant. As a result, most work stations, tools and equipment are designed and set up to accommodate right hand dominance use.

This often presents complications for the remaining 10% of the workforce. Of course there are those lucky few who are ambidextrous!

### Fitness level

#### *Job Match*

Every athlete recognizes the extreme importance of suitable physical fitness levels to perform at competitive levels. Fitness levels also have significant influence in the business and industrial environment.

- Does the worker or workforce in general demonstrate the physical fitness and functional reserve needed to safely and effectively perform the job demands?

### *Health and Wellness*

While more difficult to measure, general health and wellness of the worker has influence on ergonomics issues. Good health is the essential requisite if the body's systems are able to repair themselves in response to the everyday stresses of life including work and home activities.

## Training

Appropriate work station design is only part of the issue. The very best ergonomics design can be rendered worthless if the worker is poorly trained in its use. Training may be considered to have two primary parts.

### *Technical*

- Has the worker been adequately trained in the work process?
- Can the worker properly demonstrate the ***technical*** aspects of the job process and work demands?

### *Safety*

- Has the workforce been adequately trained in the ***safe*** performance of the job tasks?
- Has the workforce been adequately trained in methods (work station setup, tool use, breaks, stretching, and warm-up activities, etc.) to control job fatigue?

## Work Experience

An experienced, well-seasoned workforce is a valuable resource. We need to examine the workforce in terms of level and scope of experience.

### *Level*

- What is the general work experience level of the workforce or worker?
- Is the level of experience considered to be a significant factor in performing the job task?

### *Scope*

- What is the scope of experience of the workforce or worker?
- Are they cross-trained in other job demands; are they able to deal with emergency situations, etc.?

- Is the scope of experience of the workforce or worker considered to be a significant issue?

## Work Station

The general design and set-up of the work station is an important factor. We will examine a number of factors to adequately assess the work station.

### *Stationary/Mobile*

- Is the work station stationary - used primarily in one position? (See below for adjustability features.)
- Is the work station mobile - taken from job site to job site? If so, how is it transported?

### Adjustability features

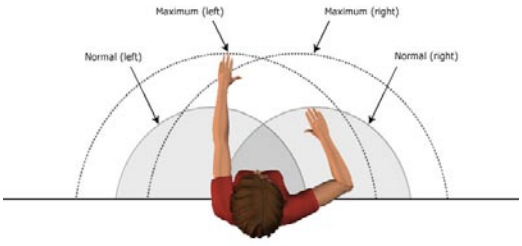
Can the work station be adjusted to accommodate the needs of different workers and work processes?

*Work height*

- Does the height of the work surface permit a comfortable view of the job being done?
- Is the height of the work surface adjustable?
- Does the height of the work surface permit satisfactory arm posture? (Correct hand height depends on type of work performed and object worked on.)

*Work reach envelope*

- Can the worker keep horizontal stretches within the range of normal arm reach?
- Refer to the anthropometric data tables for additional details.




### Chair/stool

- If a chair/stool is provided, is its design satisfactory? (Adequate back support, vertical adjustability, etc.)

### Equipment controls

- Can equipment controls and machinery be adjusted to accommodate the needs of different operators?

### Worker movement

- Is it possible for the worker to alternate sitting and standing when performing the task?

### Space and clearance

- If containers are used, are they placed conveniently?
- Is there adequate space at the work station to perform the work comfortably?
- Does the positioning of equipment controls and work surface make it possible to maintain a comfortable posture?
- Is the workplace accessible to material handling equipment?
- Is clearance space in the workplace adequate for maintenance tasks?

## *Tools*

### Manual to Power

A switch from manual hand tools to power tools can reduce force levels. Power tools create their own set of issues, including vibration and torque reaction force.

### Torque reaction forces

Torque reaction occurs when a fastener reaches the end of its travel, transferring the torque to the tool and operator. Employ clutches and torque reaction bars to reduce torque reaction forces.

Newer tools make use of pulse rather than impact technology. These tools significantly reduce power grip force requirements.

### Handle size

Handle size should be monitored to provide optimum power grasps.

Trigger configuration should spread the required triggering force over a large area, rather than concentrated in a smaller area.

### Preventive Maintenance

Preventive maintenance, based on manufacturer specifications, is critical to ensure proper operation of the tool. Sharp bits, blades, and un-clogged abrasives significantly reduce the force required to use manual or power tools.

## *Machinery/Equipment*

Part of the work station is the machinery/equipment used in the operation. Look for a number of factors.

### Foot pedals

- Are foot/knee control pedals used?
- Does the operator have to operate foot/knee pedals while standing?
- To operate foot pedals or knee switches, must the worker assume an unnatural or uncomfortable posture?
- Are pedals limited to two?
- Are pedals too small to allow the operator to alter the position of the foot/knee?
- Are pedals triggered at a high repetition rate?

### Hand controls

- Are hand controls used?
- Placed to allow neutral hand/arm/body position?
- Difficult (require excessive force) to operate?
- Designed (shape and configuration) to take into account the amount and types of force required for operation?

### *Personal Protective Equipment (PPE)*

Personal protective equipment is an essential complement to an effective ergonomics process.

### Mandatory

- Are there conditions that require personal protective clothing or equipment?
- What conditions exist?
- What PPE is used?

### Monitoring and Enforcement

- How is PPE use monitored?
- Are PPE policies enforced?

### *Physical Demands*

### Metabolic Load

- Does the job involve peak loads of muscular effort?

- How often do peak loads occur and how long do they last?
- Are there signs of unacceptable fatigue on the worker's part? (i.e. profuse sweating, red flushed face, heavy and labored breathing, poor coordination, etc.)
- Is there frequent daily stair or ladder climbing?
- Is recovery time figured into the work process?

### Force - Component Fit

A poor fit of components during an assembly process may force an assembler to "bang in" the component using the hand or other body part as a hammer. Coordinated effort with the vendor, in house or off site, can ensure the needed fit quality.

The type of fastener used may be at issue. Options include use of riveting, spot welding, and use of specialized fastening systems rather than slotted fasteners.

### NIOSH Work Practices Guide for Manual Lifting

The NIOSH Work Practices Guide for Manual Lifting was initially introduced in 1981. Industry and government representatives recognized that manual material handling was a significant problem in industry and felt guidance in controlling how much weight could be safely lifted was needed.

A lifting equation was derived from 4 primary bodies of knowledge: epidemiology, biomechanics, psychophysics, and physiology. The original equation was modified in 1991 (and published in 1993) to compensate for two factors that were not accounted for in the original equation is far- hand-to-container coupling and asymmetry of the lift. Some of the original factors were modified as well.

The present equation allows calculation of a **Recommended Weight Limit (RWL)**, defined as the load that 99% of men and 75% women could handle safely. The **Lifting Index** is also calculated, which provides guidance in the severity of the problem and scope of interventions recommended to improve it.

The revised lifting equation for calculating the Recommended Weight Limit (RWL) is based on a multiplicative model that provides a weighting for each of six variables: RWL = LC × HM × VM × DM × AM × FM × CM.

*LC = Load Constant* (51 pounds

*HM = Horizontal Multiplier* (10/H)

**Horizontal location of the hands (H):** The horizontal location of the hands at both the start (origin) and end (destination) of the lift must be measured. The horizontal location is measured as the distance from the mid-point between the employee's ankles to a point projected on the floor directly below the mid-point of the hands grasping the object (the middle knuckle can be used to define the mid-point). The horizontal distance should be measured when the object is lifted (when the object leaves the surface).

*VM = Vertical Multiplier* (1 - (0.0075|V-30|))

**Vertical location of the hands (V):** The vertical location is measured from the floor to the vertical mid-point between the two hands (the middle knuckle can be used to define the mid-point).

*DM = Distance Multiplier* (0.82 + (1.8 / D)

**Travel Distance of the load (D):** The total vertical travel distance of the load during the lift is determined by subtracting the vertical location of the hands (V) at the start of the lift from the vertical location of the hands (V) at the end of the lift. For lowering, the total vertical travel distance of the load is determined by subtracting the vertical location of the hands (V) at the end of the lower from the vertical location of the hands (V) at the start of the lower.

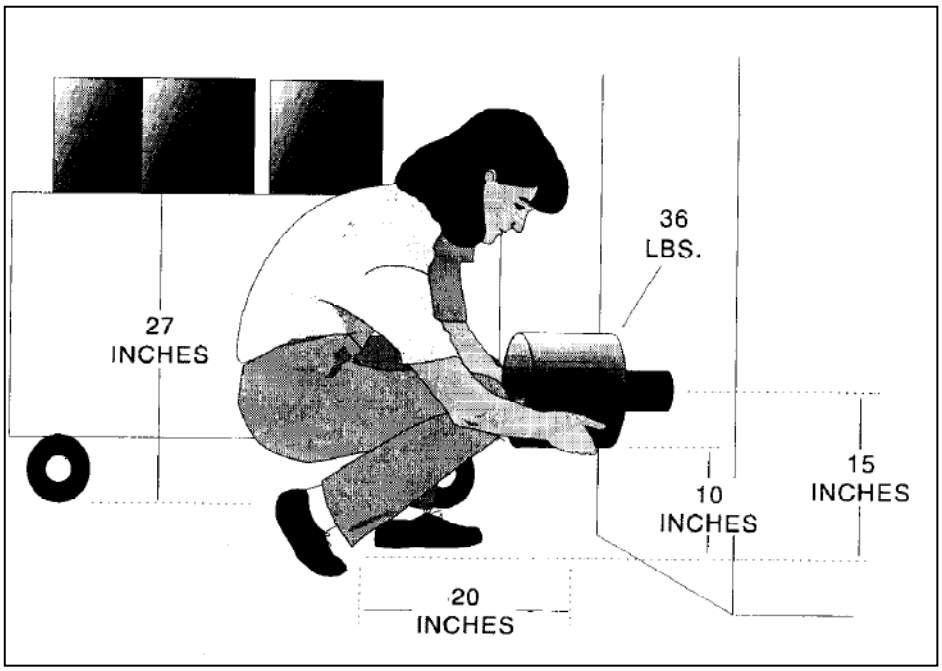
*AM = Asymmetric Multiplier* (1 - (0.0032A))

**Asymmetry Angle(A):** The angular measure of the perpendicular line that intersects the horizontal line connecting the mid-point of the shoulders and the perpendicular line that intersects the horizontal line connecting the outer mid-point of the hips.

*FM = Frequency Multiplier*

**Lifting Frequency (F):** The average lifting frequency rate, expressed in terms of lifts per minute, must be determined. The frequency rate can be determined by observing a typical 15 minute work period, and documenting the number of lifts performed during this time frame. The number of lifts observed is divided by 15 to determine the average lifts per minute. Duration is measured using the following categories: **Short** (Less than one hour); **Moderate** (1 to 2 hours); **Long** (2 to 8 hours).

*Example: Loading Supply Rolls*



## JOB ANALYSIS WORKSHEET

DEPARTMENT: Shipping
JOB TITLE: Packager
ANALYST'S NAME:
DATE:
JOB DESCRIPTION: Loading paper supply rolls
Example 2

**STEP 1. Measure and record task variables**

| Object Weight (lbs) | | Hand Location (in) | | | | Vertical Distance (in) | Asymmetric Angle (degrees) | | Frequency Rate | Duration | Object Coupling |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Origin | | Dest | | | Origin | Destination | lifts/min | (HRS) | |
| L (AVG.) | L (Max.) | H | V | H | V | D | A | A | F | | C |
| 35 | 35 | 15 | 27 | 20 | 10 | 17 | 0 | 0 | <.2 | <1 | Poor |

**STEP 2. Determine the multipliers and compute the RWL's**

RWL = LC x HM x VM x DM x AM x FM x CM

ORIGIN: RWL = 51 x .67 x .98 x .93 x 1.0 x 1.0 x .90 = 28.0 Lbs

DESTINATION: RWL = 51 x .50 x .85 x .93 x 1.0 x 1.0 x .90 = 18.1 Lbs

**STEP 3. Compute the LIFTING INDEX**

ORIGIN: LIFTING INDEX = OBJECT WEIGHT (L) / RWL = 35 / 28.0 = 1.3

DESTINATION: LIFTING INDEX = OBJECT WEIGHT (L) / RWL = 35 / 18.1 = 1.9

The weight to be lifted *(*35 lbs.) is greater than the RWL at both the origin and destination of the lift (28.0 lbs. and 18 lbs., respectively). The LI at the origin is 35 lbs./28.0 lbs. or 1.3, and the LI at the destination is 35 lbs./18.l lbs. or 1.9. These values indicate that this job is only slightly stressful at the origin, but moderately stressful at the destination of the lift.

### *Redesign Suggestion*

The first choice for reducing the risk of injury for workers performing this task would be to adapt the cart so that the paper rolls could be easily pushed into position on the machine, without manually lifting them.

If the cart cannot be modified, then the results of the equation may be used to suggest task modifications. The worksheet indicates that the multipliers with the smallest magnitude (i.e., those providing the greatest penalties) are .50 for the HM at the destination, .67 for the HM at the origin, .85 for the VM at the destination, and .90 for the CM value. The following job modifications are suggested:

1. Bring the load closer to the worker by making the roll smaller so that the roll can be lifted from between the worker's legs. This will decrease the H value, which in turn will increase the HM value.
2. Raise the height of the destination to increase the VM.
3. Improve the coupling to increase the CM

If the size of the roll cannot be reduced, then the vertical height (V) of the destination should be increased. If V was increased to about 30 inches, then VM would be increased from .85 to 1.0; the H value would be decreased from 20 inches to 15 inches, which would increase VM from .50 to .67; the DM would be increased from 0.93 to 1.0.

Thus, the final RWL would be increased from 18.1 lbs. to 30.8 lbs., and the LI at the destination would decrease from 1.9 to 1.1.

In some cases, redesign may not be feasible. In these cases, use of a mechanical lift may be more suitable. As an interim control strategy, two or more workers may be assigned to lift the supply roll.

*Comments*

The horizontal distance (H) is a significant factor that may be difficult to reduce because the size of the paper rolls may be fixed. Moreover, redesign of the machine may not be practical.

Therefore, elimination of the manual lifting component of the job may be more appropriate than job redesign.

### Force - Lift/Push/Pull (Manual Material Handling)

Manual material handling is commonly seen in many diverse settings, not just in warehouses. OSHA has identified the stresses associated with manual material handling as one of the major factors to examine and alleviate.

Force levels are a function of the weight of the tools, containers, boxes, parts, carts, etc. Whether lifted, carried, pushed, or pulled, the force required to move or manipulate the object directly creates stress on the body.

*Questions*

- Do workers have to lift objects, boxes, parts, materials?
- Does the task require:
  - Strenuous one-hand lifting?
  - Strenuous two-hand lifting?
  - Lifting over too great a vertical distance (near floor or above shoulders)?
  - Lifting at too great a horizontal distance?
  - Difficult-to-grasp items?
- Does the job require handling of oversized objects?
- Does the job require two-person lifting?
- Is help for heavy lifting or exerting force unavailable?
- Do workers have to push or pull objects?
- Does the task require:
  - Large breakaway forces to get the object started?
  - Pushing or pulling hand trucks or carts up or down inclines or ramps?

- Does the job lack material handling aids such as air hoists or scissors tables?

*Intervention strategies*

Intervention strategies to control force levels related to the weight of the load include:

- Design job to reduce static muscle loading. (Provide jigs, fixtures, clamps, spot welds, etc. to hold work object.)
- Workers learn how to better control static muscle loading. (Body mechanics, stretching, etc.)
- Make use of mechanical devices, hoists, lifts, etc. to eliminate manual lifting.
- Slide rather than lifting the weight.
- Eliminate the effect of gravity by counterbalancing the weight, a method commonly used with tools.
- Remove physical barriers, thereby reducing the horizontal distance (long lever arm).
- Relocate storage heights with heavier objects stored between mid- thigh and waist height.
- Work with vendors to provide material either in smaller unit weights (e.g., 50 pounds, rather than 100 pounds) or in bulk that requires handling with mechanical means.
- Provide adjustable height surfaces (e.g., scissors tables) to maintain desired height of material.
- Reposition the worker to provide greater mechanical advantage; e.g., use body weight rather than musculoskeletal strength.
- Reposition the work material; e.g., bring parts and tools within reach envelope; place bin on a bin tipper or provide side drop-down bins

The safest lift of all is the one that does not occur. Whenever possible slide objects rather than lift them. Friction between the surface and object may be a problem. Friction can by decreased by:

- Line storage shelves with decreased friction liners (e.g., Teflon sheets).
- Spray-on products will reduce friction (may cause a toxic substance problem.)
- Use roller conveyor systems to transport materials.
- Maintain the quality of floor conditions to eliminate cracks and general deterioration.
- Use appropriate type and size of casters or wheels as original equipment or retrofit, depending on floor type.

**Force - Workflow and Rate**

The factors of workflow and rate contribute to the effect of force on the musculoskeletal system. The duty cycle of the job demand determines the force dose-exposure.

Reducing either the dose (level of force) or the exposure (duration of the force) is desirable. Reduce exposure through administrative controls including job rotation and job enlargement.

## Force - Grip

Whether using tools or handling boxes, grip has a major influence on controlling force levels. A power grip makes use of larger, more powerful muscles than does a pinch grasp.

Typically, a maximal pinch is only 20% of maximal power grasp. Adjusting coupling can facilitate the use of power grips. Grip spans of 1 1/2 to 2 inches are ideal. Spans greater or less result in less than desirable mechanical advantage.

*Questions:*

Is a power grip used?

- For what purpose is the grip used?
- Do workers have to exert high levels of power grip force to perform tasks?

Is a pinch grip used?

- For what purpose is the grip used?
- Do workers have to exert high levels of pinch grip force to perform tasks?
- Can a change to a power grip be made?
- Can the grip be eliminated or reduced?

*Coefficient of Friction*

The coefficient of friction can have a major impact on controlling grip force levels. Friction between the hand and object can be increased by:

- Use rubberized coating on the object; e.g., tool handle.
- Clean the object of lubricants.
- Provide appropriate non-slip gloves.
- Maintain normal skin moisture; dry skin has about 2/3s the coefficient of friction compared to moist skin.

### Glove use

Gloves are commonly seen in work environments. The type and fit of the glove should reflect the purpose of the glove. Determine if the glove is truly necessary.

Generally, a gloved hand is able to produce a maximum of 25% to 30% less force than an ungloved hand. A ***"one size fits all"*** policy does not work. Gloves that are too small increase the force required to overcome the resistance of the glove. Gloves that are too large hinder dexterity due to sloppiness of fit.

### *Position*

The goal is to have the body in a neutral posture as much as possible. Evaluate jobs or activities that tend to force the worker out of ergonomic neutral positions and/or result in awkward or sustained positions.

### Prolonged or repeated non-neutral spinal positions

Non-neutral spinal positions include bending the head, neck, and trunk forward, backward or to the side, with or without twisting.

### Wrist deviations greater than 15 degrees from neutral

You can demonstrate the neutral position at the wrist by making a tight fist. This results in approximately 10-15 degrees in extension in most people, and is the position of power for the wrist. This posture enables maximum force production while maintaining space within the carpal tunnel.

As the wrist moves away from this power position, the finger flexor tendons increase their contact against the carpal ligament or bones of the wrist. This increased contact may result in inflammation, and the pressure within the carpal tunnel may increase.

### Forearm rotation

When the forearm is rotated toward the extremes of supination (palm up) and pronation (palm down), in combination with deviations of the wrist from the power position, there is a great degree of stress at the origin of the forearm muscles.

### Elbows sustained above mid-chest height

Elbows positioned above mid-chest height place additional stress on the shoulder when prolonged muscle contractions are required. In addition to inefficient use of energy, these positions also tend to cause a reduction in blood flow to the tendons in the shoulder.

### Reaching frequently behind the body or above the shoulders

Arm positions behind the body or above the shoulders tend to increase pressure within the shoulder joint while stretching many of the shoulder tendons and muscles.

## *Modifying Work Positions*

### Standing work position

Standing positions are more appropriate than sitting positions if:

Frequent or relatively heavy lifting is required.

Significant downward forces are required.

### Seated work position

Use seated work stations when light assembly or precision work is performed.

### Sit/Stand work positions

In some cases sit/stand work stations may provide a viable option. These provide for postural variability.

### Adjustable height work stations

Adding adjustable height work stations and lift tables to a work area allows for increased postural variety for workers but also allows accommodation for variation in body stature between workers.

### Turntables

Use turntables to bring parts closer to the worker, reducing the need for sustained or extreme forward reaching.

These are particularly helpful when the worker needs to access the other side of the pallet.

### Movement

Even relatively well-designed ergonomic work stations require individuals to work in one posture. Evaluation of the work place should include an assessment of how often individuals have the opportunity to move out of sustained postures to perform other movements or tasks.

### Tool use and postures

Frequently workers use tools specifically designed for another purpose. This is often found when using pistol grip and in-line tools.

*In-line grip*

An in-line power tool is used when there is need for a vertical drive that occurs between the waist and elbow height.

*Pistol grip*

Use pistol grip tools on horizontal surfaces at waist height or for vertical surfaces between elbow and shoulder height. In the past decade, tool manufacturers have made major strides in the design of ergonomically approved tools.

Such tools include bent handle pliers, ergonomic knives, reduced vibration power tools, etc.

### Rapid machine pacing in an assembly task

Production workers performing machine-paced tasks are frequently required to maintain a work rate greater than they can perform comfortably.

In many cases, workers work ahead to create a buffer, for fear that they may fall behind.

Other workers find themselves working behind the line because they can not keep pace.

Both situations require individuals to work in positions other than directly in front of them, promoting awkward postures.

### Reach envelope

Examine the work station layout regarding placement of tools, parts, or materials to promote a reasonable reach envelope. A desirable reach envelope is laid out horizontally within a $45^{o}$ arc from midline to each side of the body.

The amount of forward reach is also considered, recognizing that items stored above or below shoulder height need to be closer to the worker than those stored at shoulder height.

### Storage locations

Place the most frequently used materials, tools and controls at optimal positions within the reach envelope.

Incline the work station and/or use rotating jigs and turntables to bring parts or materials close to the person when required.

## *Repetition*

Repetition rates can be difficult to reduce due to production standards. However the associated stresses can be controlled in a number of ways.

### Mechanical Aids

Reduce repetition rates through the use of mechanical aids.

- Introducing power tools in the work place may reduce duration of forceful contractions and awkward and sustained positions.
- Mechanical aids can also automate all or parts of a work process.
- The operator's exposure to the stresses associated with high repetition is reduced without reducing the output.

### Worker Rotation

A feasible alternative to reducing repetition rates is the use of worker rotation. Worker rotation reduces overall exposure of workers to particular types of repetition.

Analyze work methods when you implement worker rotation system; the required motions for each body part should be identified.

After determining that designs are acceptable or that redesign is not feasible, workers should be cross-trained to perform each job within a rotation schedule.

In addition to involving the workers in identifying a successful rotation strategy, it is also important to ensure that jobs into which workers rotate involve significantly different physical job demands.

**In some cases, job rotation schemes rotate individuals through different jobs, but the actual physical demands are very similar from position to position. This is not a beneficial use of worker rotation.**

### Pay System

The type of pay schedule is directly related to the pace at which an individual works. Incentive, piece-rate systems can actually drive workers to perform at higher rates than are considered desirable.

### Add Staff

In some situations, it may be worthwhile to consider the addition of staff members. The cost per unit may increase based on this protocol. Weigh the effect on production, quality, employee morale, and the risk of overall cumulative trauma against this additional cost.

### Reduce Line Speed

In some situations, it may be possible to reduce the speed of the line, or to change from a machine-paced to a self-paced work environment

### Questions:

*Repetition - Pacing*

- Is the work pace rapid?
- Is the work pace under the worker's control?
- Is the pace of material handling determined by a machine? (Feeding machines, conveyors, etc.)

*Repetition - Manual Handling*

- Are workers frequently required to lift and carry heavy weights?
- Does the task require the worker to repeat the same movement pattern at a high rate of speed?

*Repetition - Arm/Hand*

- Does the task require the worker to repeat the same movement pattern at a high rate of speed?
- Does the task require the continuous use (or nearly so) of both hands and both feet in order to operate controls or manipulate the work object?

*Repetition - Tool Use*

- Does the job involve the frequent use or manipulation of tools?
- Are power tools in use?
- Are manual tools in use?
- In some cases, rivets, welding, or adhesives may replace the need for screw fasteners.

## *Vibration*

### Whole body vibration

Truck and forklift drivers frequently encounter whole body vibration. Vibration of this type is suspected of weakening and disrupting soft tissue structures such as tendons and ligaments.

### Questions:

- Is the body as a whole subjected to vibration?
- Is the level of vibration high enough to have adverse effects on the worker?

### *Segmental vibration*

Segmental vibration is typically found in tasks that require the use of abrasive wheels, grinders, lathes, and power hand tools. Vibration from these sources has been shown to decrease sensitivity in the hand, resulting in an unnecessary increase in local muscle contractions.

### Associated with other factors

- As with force, posture, repetition, and contact stress, vibration is frequently associated with other risk factors.
- Assess the duration of the exposure, the exposure patterns during the shift, and the force levels and postures assumed during the vibration exposure.

### Fastener types

Fastener types used with various power drivers and nut runners may also play a role in vibration exposure. Certain fasteners, because of the manner by which they engage the power tool, may drive more easily resulting in reduced exposure to vibration, sustained or high force levels, poor postures and contact stresses.

- Hex head screws drive faster and with less effort than Phillips screws and Phillips screws less so than slotted screws.
- In some cases, rivets, welding, or adhesives may replace the need for screw fasteners.
-

### Questions

- Is there tool vibration?
- Is the level of vibration high enough to have adverse effects on the worker?

Control vibration

### Source control

When possible try to control vibration at the source. This is important whether the vibration is segmental or whole body in nature.

- Maintain and balance power tools on a regular basis.
- Evaluate the floor quality.
- Repair work, or even replacing vehicle seats, may be necessary to reduce exposure to whole body vibration.

### Path control

In many situations, it may not be possible to control vibrations at the source. In this situation, obstruct and dampen the path of the vibration.

- Vibration attenuation covers that attach directly to the tools.
- Wear gloves with padded palms.
- When you add these coverings, be aware the effective handle diameter increases and tool control and grip strength may be adversely affected.
- Increasing the speed (RPM) at which the tool turns, frequently helps to reduce the amplitude of the vibration.
- Quick-cutting abrasives in grinding and sanding operations.

### *Contact Stress - Sharp edge*

When you evaluate the type and severity of contact stress, look for any part of the body that is in contact with a sharp edge.

- Examine tool handle size and shape for prominences that promote increased pressure over any point of the grasping surface of the hand.
- Evaluate tools regarding the amount of localized pressure tools produce in the palm of the hand.
- Finger contours on handles or triggering devices of tools may also produce unnecessary stress on the digits.

- Examine the size and shape of any machine guards for potential contact stress. Identify and correct sharp edges or sustained pressure on the guard.

### Control strategies - round edges

- Round work surface edges that come in contact with the worker.
- Tool handles and trigger switches should have rounded contours.
- Avoid the use of tools that require continuous or intermittent pressure on the fingers, palm, base of the wrist, forearm, and elbow.
- When possible, use self-opening tools such as pliers and scissors that are spring loaded. This reduces contact stresses required to open the tool.
- When contact stress itself cannot be avoided, the goal is to distribute the pressure over as large an area as possible by increasing the contact surface area.

### Questions:

- Is the worker in contact with sharp edges in the work place (machine guards, tool handles, desk edges, etc.)?

### Use of the hands for pounding

Nerve and soft tissue trauma may occur when the hands are used as hammers. Using the hands in this manner increases the likelihood of local inflammation that may cause unnecessary scarring.

Eventually reduction in blood flow to the nerves and other soft tissues may occur. Inappropriate techniques and work processes are frequently the culprit regarding contact stresses.

Encourage workers to be aware of potential problem areas such as pressure over vulnerable areas of the body where nerves and blood vessels are close to the surface.

Hands are NOT hammers!

### *Contact Stress – Sitting and Standing*

Two areas of the body that are frequently not evaluated for contact stress are the feet of people who stand all day, and the buttocks and thighs of those who sit all day.

Evaluate chairs by observing any pressure at the front of the seat pan and the position of the backrest. Evaluate the potential for pressure behind the knee or at the back of the thigh caused by the edge of the seat pan.

Floor surfaces can affect the comfort of workers who are required to stand for a large percentage of the day. This is a problem particularly when there is limited potential for movement.

Concrete, steel grates, uneven or vibrating floor surfaces may increase foot, leg or spinal fatigue and discomfort and can affect concentration and product quality. Anti-fatigue mats or shock absorbing shoe inserts can improve comfort levels.

### Questions:

*Contact Stress - Hard surface*

- Must the worker stand on a hard surface for 45 percent or more of the work shift?
- Is the texture of the work surface comfortable, taking into account hardness, elasticity, color and smoothness?

### *Mental Demands*

The mental demands of work can be just as demanding and stressful as the physical demands. They require a thoughtful examination.

### Is the task complex?

- Does the worker have to evaluate data before taking action?
- Must the operator sense and respond to information signals occurring simultaneously from different machines without sufficient time to do so?
- Must the operator process information at a rate, which might exceed his or her capability?
- Is the job so complex it takes a long time to train workers?
- Does the task require a great deal of accuracy?
- Does this work situation require monitoring several machines?

### Is the tack monotonous?

- Does the worker repeat the same task without change for the entire shift?
- Does the worker loose track of the task at hand because it is overly monotonous?

### Design and Use Standards

- Are controls standardized on similar equipment?
- Does the design of any instrument increase reading errors?

### *Perceptual Demands*

Our ability to properly perceive our environment exerts a major influence on our interaction with it.

Issues like illumination, auditory, touch and visual acuity fall into the realm of perceptual demand.

### Illumination

Evaluate the quantity and quality of light. In many cases, today's office buildings have illumination levels approximately 25 to 30 per cent greater than desirable. Decreasing the amount of general overhead light and bringing in specific task lighting is effectively in selected areas.

Also, consider the overall quality and level of the light in relation to the color and reflectivity of the walls, floors, and ceilings. Glare is a commonly observed problem in office environments where it is apparent on video display terminals (VDT) screens.

Under-illumination facilitates forward bending of the trunk and head as individuals attempt to get closer to the material they are viewing. Task lighting can be effective to focus illumination where desired and at the same time control glare.

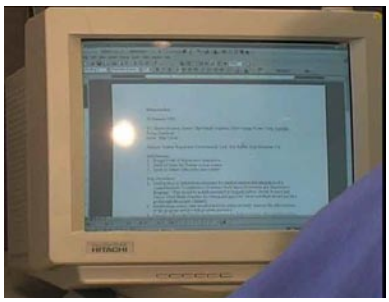
*Illumination - General*

- Is special lighting necessary to perform the job?
- Is the general work area including egress/ingress poorly lit?

*Illumination - Task*

- Is lighting inadequate for the job?
- Are controls, instruments and equipment poorly lit?
- Is the illumination not satisfactory for the task?

*Illumination - Contrast*



- Is contrast poor between the workspace and its surroundings?
- Is the workplace so poorly lit that there are great differences between brightness levels in panels, dials and surroundings?

*Illumination - Glare*

- Is glare present in the workplace?
- What is the source of the glare?

- Is glare from displays a problem?

### Auditory

- Does the noise level prevent or impair verbal communication?
- Are there auditory signals?
- Are some auditory signals hard to hear in general?
- Are auditory signals difficult to distinguish from one another?

### Touch

- Is there a need to tell the difference between parts by touch?
- Is it difficult to recognize controls and tools by touch and/or position?

### Visual Acuity

- Does the task require fine visual judgments? (This includes the need to detect small defects, judging distances accurately, etc.)
- Are dials and instruments difficult to read quickly and accurately?
- Are controls, instruments and equipment placed where they are difficult to see? (At a bad angle, too high, too low.)
- If warning lights are present, are they located out of the center of the field of vision?
- Are dials grouped inconveniently?

### Preventive Maintenance

Preventive maintenance of tools, equipment, work stations and the facility itself have a major impact on the workforce.

*Regular schedule*

- Is there a regular maintenance schedule?

*Ease of maintenance*

- Is the equipment designed or placed in such a way that cleaning and maintenance activities are difficult?
- Are containers designed for easy maintenance and repair?
- Does the design of the equipment allow for easy access for maintenance and repair?

- Are floors uneven?

### Housekeeping

*General*

- Is the workplace floor clear of clutter and obstructions, which could create the risk of slips, trips or falls?
- Are floors slippery?

*Work station*

- Does there seem to be too much clutter in the work station?
- Is housekeeping at the work station poor?

## *Environment*

### Cold

Cold environments, tools, or pneumatic tool exhaust may bring about a reduction in tissue sensitivity, manual dexterity, and grip strength.

When sensitivity decreases the amount of force exerted to perform a task increases. This requires the individual to perform more work than necessary.

- Adequate personal protective equipment and appropriate worker rotation (in and out of cold environment) are also effective.
- Directing tool exhaust away from the user is important for maintaining tissue sensitivity.

### Heat

Hot environments result in an increase in metabolic demand. Heat may also affect an individual's ability to grasp tools and parts and to manipulate controls due to the effect of perspiration on grasp.

- When perspiration increases, friction between the hand and the tool decreases. Higher force levels are again required to maintain the integrity of the grasp.
- Hot and humid environments may also result in the fogging of eye protection, again complicating effective task completion.
- Adequate ventilation and clothing as well as worker rotation are effective.

### Air

*Temperature*

- Is the air temperature too cold? Too hot?
- Is it too humid in the workplace?
- Are radiant heat sources placed near any work stations?

- Are there rapid changes in temperature in the work environment?

*Quality*

- Is there so much air contaminant in the process that it settles on displays, making them difficult to see?
- Are suspended dust, mists and other particulates present in the air?

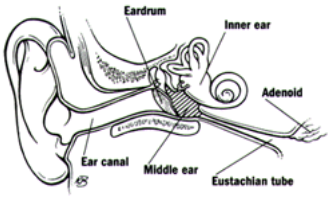
*Flow*

- Is air circulation too low?
- Is there too much air movement?
- Are workers exposed to rapid environmental changes?

*Humidity*

- Is the humidity frequently uncomfortable enough to interfere with the job?
- Are there wet locations that may produce shock hazards for work with electrically powered equipment?

### *Noise*




Noise is any unwanted sound. One person's music may be another person's noise. Potentially damaging noise is frequently encountered in work environments.

Noise has basic components of frequency, level, and duration. Frequency, or pitch, is measured in Hertz (Hz), or cycles per second; the higher the frequency, the higher the pitch. The range of human hearing is 20 Hz to 20 kHz. Noise is measured in decibels (dB) and is perceived as loudness.

For example:

- 60 dB - social conversation.
- 80 dB - conversing in loud noise less than one foot away.
- 105 dB - jet engine.
- 150 dB - reduced visual acuity, chest wall vibration, "gagging" sensation. Sounds may have a very short duration, such as the crack of a rifle, or a long duration, such as the engine of an industrial generator.

High noise levels can drastically impede effective communication in the workplace. Concentration is affected, negatively influencing productivity. Noise has also been blamed for excessive fatigue.

### Noise Abatement

Because noise is essentially another form of vibration, intervention strategies are similar to those for the control of vibration.

Controlling noise at its source is always the best possible solution. For example, replacing noisy dot matrix printers with laser printers can be effective in office environments.

If it is not possible to control the source of the noise, changing its path can also control it. Use acoustical sound barriers, enclosures, and sound absorbing tiles and carpet.

### Noise - Questions

- Is there so much process noise that hearing loss could occur?
- Is there so much noise that it interferes with speech or audible signals of various kinds?
- Are there noise levels that interfere with conversation or performing the job?
- Is the noise level high enough to cause hearing loss?

## Work Process

The work process component really includes all of the factors we have discussed and integrated them into the whole picture of a successful workplace.

### *Look at the whole picture*

Looking at the entire picture is an essential part of the ergonomics analysis and modification. The goal is to:

- Design work to take into account basic predictable human behavior.
- Provide an adequate level of job complexity and challenge.
- Involve the worker in the design process.
- Implement engineering, work practice and administrative control as appropriate.

### *Management/Supervision*

Management and supervision issues are included in the work process component. With out appropriate management of the work place ergonomics interventions will not be effective. These factors include:

- Labor/management relationships
- Supervision given and received
- Peer interaction
- Corporate philosophies and management style

In other words all of those tangible and intangible factors which make up the "culture" of the organization.

As noted, management's commitment to, involvement in and facilitation of the ergonomics process is critical to its success. Significant evidence suggests that a management team who sends the message "we care" has major impact on controlling workplace injuries and illnesses and enhancing productivity and quality.

### *Establish clear performance goals and objectives*

- Establish a clear mandate for a safe and productive work environment.

- Provide adequate employee reporting system with supervision.
- Develop effective relationships in all aspects of the organization.
- Ensure adequate training and re-fresher training.

### *Questions*

- Does it take too long to train workers- for certain tasks?
- Do workers make frequent mistakes?
- Are absenteeism and accident rates unusually high?
- Are incentive pay system used?
- Is production efficiency too low?
- Is there too much equipment damage?
- Is there too much waste material resulting from production?
- Is product quality low?
- Are workers frequently away from their work stations?
- Are employees making subtle workplace changes?
- Are work stations used during more than one shift each day?
- Are plant engineers familiar with ergonomic principles?

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## Professional Organizations

American Industrial Hygiene Association
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American Society of Safety Engineers
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Human Factors and Ergonomics Society
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International Ergonomics Association
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## Web Sites

Many, many, many web sites have ergonomics related content.

Here are a couple of the better ones:

www.ergoweb.com

www.osha.gov

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