

Material Handling Classics™

Papers in the classics series have appeared in previous publications of the Material Handling Institute and are at least ten years old. Nonetheless, their value in contributing to the evolution of the industry and to current practice is viewed to be timeless, even though in many cases the authors and companies credited are no longer in the industry.

ERGONOMICS: MAXIMIZING THE HUMAN RESOURCE

1986 Logistex Forum
May 6-8, 1986

BRIAN E. MCNAMARA
SOUTHWORTH INCORPORATED

Every business in industrial America has trembled with the self-doubts which result from the staggering amounts of evidence which conclude that our domestic productivity has not kept pace with foreign competition. In a reaction to this growing concern, an extraordinary amount of attention has been focused on the fields of automation and robotics. Management's have and will continue to invest millions of dollars to renovate plants, control inventories and automate operations. These programs are not only worthwhile but also an absolute necessity if our companies are to remain competitive contributors in the marketplace. However almost completely lost in this race to automate is the need to enhance the efficiency of the workers who populate our factories and warehouse.

Almost any annual report will clearly show that despite automation, robotics, JIT systems and all other current innovations, most companies still show wages and salaries as their number one expense. Human resources are still the key element in industry and will continue to account for a significant share of every company sales dollars. Accordingly, simple business economics clearly reveals that even marginal improvements in this huge cost component will have a dramatic impact on profitability. We must then strive to gain optimum performance from our human resources with the same intensity that we attempt to gain maximum utilization of our facilities, equipment and materials.

Ergonomics

In the industrial workplace, ergonomics is generally defined as a variation of the following:

A science devoted to determining the range of anatomical, physiological and psychological human factors and designing work environments conducive to these ranges with the objective of maximizing productivity and minimizing injury (see Fig. 1).



8720 Red Oak Boulevard Suite 201
Charlotte, North Carolina 28217-3992

Material Handling Classics
Page 1 of 13

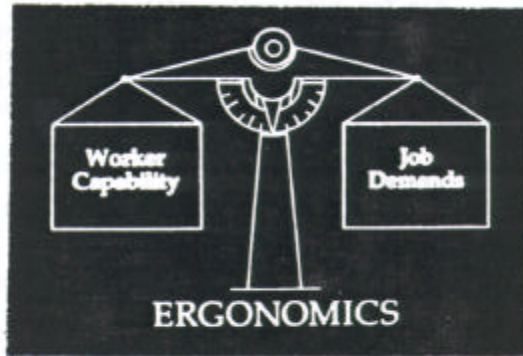


Figure 1

Great strides have been made in this relatively new field also known as human factors engineering. Ergonomic research has provided many important advances in our understanding of the dynamics of the work environment. A great amount of study has been devoted to anthropometrics, which is the study and technique of human body measurement. This research has furnished valuable information regarding a worker's physical capabilities and limitations (see Fig. 2).

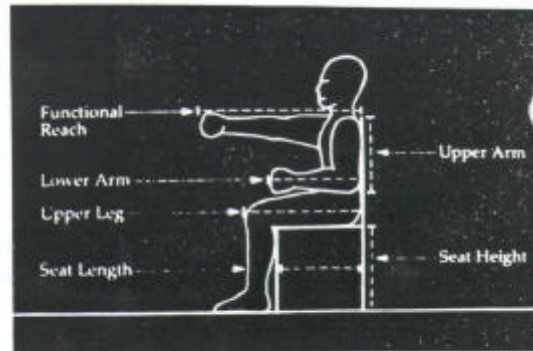


Figure 2

The determination of this physical variable from functional arm reach to proper sitting position allows the workplace to be engineered to accommodate the greatest range of the working population. These ergonomic studies have determined that many elements of the workplace, such as machinery design, noise, working heights, ventilation, heat, control design and lighting, have direct impact on the worker (see Fig. 3.)

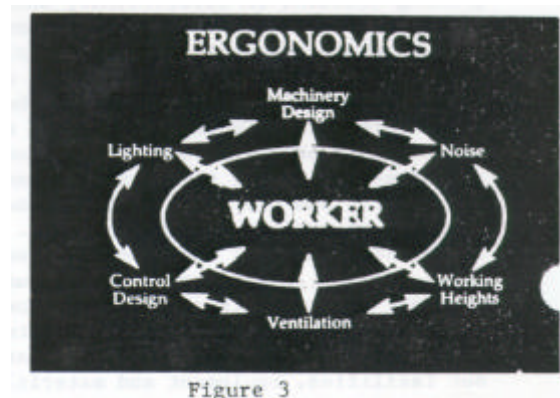


Figure 3

Furthermore, they have measured how variations of these factors affect the morale, health and safety, energy expenditure and productivity of the worker. Each of which impacts the quantity and quality of output of the human resource.

For example, ideal-working heights is a fundamental exploration of ergonomics. In one foundry study, manipulating the surface height of workstations produced dramatic variations in worker output. When each individual's ideal work surface height was determined; they measured a constant 40% improvement in the worker's production.

Finally, the information resulting from these various research projects is allowing comprehensive guidelines to be developed, such as, Liberty Mutual's Dr. Stover H. Snook's Ergonomic Principles for Manual Handling Task Design (see Table 1). The availability and utilization of this type of information is as critical to optimizing the performance of our workers as installation and operating instructions are for our complex machines.

The fact that ergonomics is an approach targeted toward maximizing the efficiency of our human resources and can sometimes produce results as significant as the foundry study certainly justifies its coexistence with the other "factory-of-the-future" techniques as worthwhile and necessary in the quest to improve the productivity of our factories and warehouses.



Ergonomic Objectives

Essentially, there are three major issues or objectives of applied ergonomics:

1. Improved Productivity
2. Enhanced Safety
3. Better Employer/Employee Relations

In evaluating the objective of improved productivity, the prime factors determining the efficiency of the work process are the worker and the workplace design. Only one of these factors, the workplace design, can be modified to suit the other. We cannot redesign the human being to suit the work process.

Table 1. Ergonomic Principles for Manual Handling Task Redesign

I. MINIMIZE SIGNIFICANT BODY MOTIONS

1. Reduce Bending Motions

A. Eliminate the need to bend by:

- Using lift tables, work dispensers and similar mechanical aids.
- Raising the work level to an appropriate height.
- Lowering the worker.
- Providing all material at work level.
- Keeping materials at work level (e.g., don't lower anything to the floor that must be lifted later).

2. Reduce Twisting Motions

A. Eliminate the need to twist by:

- Providing all materials and tools in front of the worker.
- Using conveyors, chutes, slides, or turntables to change direction of material flow.
- Providing adjustable swivel chairs for seated workers.
- Providing sufficient workspace for the whole body to turn.
- Improving layout of work area.

3. Reduce Reaching Out Motions

A. Eliminate the need to reach by:

- Providing tools and machine controls close to the worker, to eliminate horizontal reaches over 16 inches.
- Placing materials, workplaces, and other heavy objects as near the worker as possible.
- Reducing the size of cartons or pallets being loaded, or allowing the worker to walk around them, or rotate them.
- Reducing the size of the object being handled.
- Allowing the object to be kept close to the body.



II REDUCE OBJECT WEIGHTS/FORCES

4. Reduce Lifting and Lowering Forces

A. Eliminate the need to lift or lower manually by:

- Using lift tables, lift trucks, cranes, hoists, balancers, industrial manipulators, drum and barrel dumpers, work dispensers, elevating conveyors, and similar mechanical aids.
- Raising the work level.
- Lowering the operator.
- Using gravity dumps and chutes.

B. Reduce the weight of the object by:

- Reducing the size of the object (specify size to suppliers).
- Reducing the capacity of containers.
- Reducing the weight of the container itself.
- Reducing the load in the container (administrative control).
- Reducing the number of objects lifted or lowered at one time (administrative controls).

C. Increase the weight of the object so that it must be handled mechanically:

- Use the unit load concept (such as bins or containers, preferably with fold down sides rather than smaller totes and boxes).
- Use palletized loads.

D. Reduce the hand distance by:

- Changing the shape of the object.
- Providing the grips or handles.
- Providing better access to object.
- Improving layout of work area.

5. Reduce Pushing and Pulling Forces

A. Eliminate the need to push or pull by:

- Using powered conveyors.
- Using powered trucks.
- Using slides and chutes.

B. Reduce the required force by:

- Reducing the weight of the load.
- Using non-powered conveyors, air bearings, ball caster tables, monorails and similar aids.
- Using the four-wheel hand trucks and dollies with large diameter casters and good bearings.
- Providing good maintenance of floor surfaces, hand trucks, etc.
- Treating surfaces to reduce friction.
- Using air cylinder pushers or pullers.

C. Reduce the distance of push or pull by:

- Improving layout of work area.
- Relocating production or storage area.



6. Reduce Carrying Forces

A. Eliminate the need to carry by converting to pushing or pulling:

- Use conveyors, air bearings, ball caster tables, monorails, slides, chutes and similar aids.
- Use lift trucks, two wheel hand trucks, four wheel hand trucks, dollies and similar aids.

B. Reduce the weight of the object by :

- Reducing the size of the object (specify size to suppliers).
- Reducing the capacity of containers
- Reducing the weight of the container itself.
- Reducing the load in the container (administrative control).
- Reducing the number of objects lifted or lowered at one time (administrative control).

C. Reduce the distance by:

- Improving the layout of work area.
- Relocating production or storage areas.

On this premise, human factor engineering sets forth to design the workplace in such a manner that the factors, which influence human performance, are modified to create an environment, which maximizes the innate capabilities of the worker. In the area of materials handling, it is simple logic to understand that when the workplace is planned to suit the worker and unproductive, unnecessary and potentially harmful actions such as bending, twisting, reaching and lifting are eliminated:

1. Worker output will be increased by restricting energy and motion to specific production actions.
2. The quality of the output will be improved by the resultant reduction of worker fatigue and stress.

This same workplace design will also contribute to productivity improvements in a more general application by:

- Enhancing labor flexibility by expanding the availability of employees can efficiently
- accomplish the work process. Physical characteristics will not dominate the assignment of jobs.
- Tall/short, young/old, strong/weak and male/female will all be equally capable of the same work.
- Expanding production flexibility by gaining maximum utilization of the most flexible production resource, the worker. There is no mechanism, which is more easily assigned or programmed.

Finally, the process of ergonomic workplace evaluation originates a variety of cost reduction decisions ranging from minor equipment modifications to the determination that certain tasks should be automated.

The second major objective of ergonomics is enhanced safety. An obvious conclusion, which was previously stated, was that we couldn't redesign the human being to suit the work process.



Although this appears to be indisputable, the fact that the incidence and costs of workplace injuries are running rampant indicates that not-withstanding a redesign, we are demanding that the worker perform beyond his design parameters.

The Bureau of Labor Statistics reported that there were 5 million workplace injuries in 1980. The largest contributor to this total was back injuries, of which, there were 1 million or twenty percent. Other leading lost time disorders were carpal tunnel syndrome (from repetitive hand and wrist action), tendentious, vibration related and stress.

These injuries have become incredibly expensive. Depending on whose data you choose, the average direct cost of a back injury ranges from 5 to 10 thousand dollars per incident or extrapolated from the annual rate, 5 to 10 billion dollars per year. Cases of carpal tunnel syndrome generally cost between 30 to 60 thousand dollars to treat and any lost time injury will typically cost employers 8 to 10 dollars per lost hour. In addition to the direct costs, there are the indirect cost of losing a valued employee, replacement, training, absenteeism and turnover. The automotive industry calculates that the indirect cost is 50 to 10 times higher than the direct costs.

The penalty for workplace injuries continues to inflate. Today, many companies are finding it exceedingly difficult to find an insurer to cover their worker's compensation and those that do are experiencing premium shock. There is a direct correlation between a company's historical safety record and their current premiums, which means that insurance costs are controllable. The difference between a good safety record and a poor one can escalate insurance premiums by 200 to 300 percent.

Another way to understand the impact of a workplace injury is to measure the increase in sales required to recover the cost of the injury. For instance, a company generating a 4 percent profit would need to sell an additional 2.5 million dollars of goods or services to breakeven on a lifting accident, which had a total cost of \$100,000 (see Fig. 4).

Accident Cost	Company Profit Margin				
	2%	4%	6%	8%	10%
50,000	2,500,000	1,250,000	833,000	625,000	500,000
100,000	5,000,000	2,500,000	1,667,000	1,250,000	1,000,000
250,000	12,500,000	6,250,000	4,167,000	3,125,000	2,500,000
500,000	25,000,000	12,500,000	8,333,000	6,250,000	5,000,000
1 Million	50,000,000	25,000,000	16,667,000	12,500,000	10,000,000

Figure 4



It is fairly easy to see that improving safety has become far more than a quality of life issue. It is a profit issue which can be solved by the use of ergonomic principles of Task Design described in Table 1 as a guide for designing and redesigning operations involving manual material handling will create a workplace which minimizes or excludes dangerous movements and repetitive motions. This accomplishment will virtually guarantee a dramatic reduction in costly, traumatic injuries by providing workers with the practices, mechanics and products necessary to work efficiently within their physical limitations.

This ergonomic approach to workplace design also produces ideal transitional work applications. Here, employees with disabilities can be brought back to doing productive work sooner by modifying the workplace to accommodate their condition. These accommodation costs are generally minor compared to the previously described high costs of disability compensation.

The third issue involved in the practical application of ergonomics is better employer/employee relations. It is generally accepted that due to growing competitive pressures, both foreign and domestic, future labor negotiations will increasingly focus on work environment, quality of life and other social rather than pure economic issues. Furthermore, in order to build better team relations, actions must be taken and results must be achieved which truly benefit both parties. A review of the productivity and safety benefits achieved through the use of ergonomics demonstrates a positive gain for both employer and employee. The employer achieves:

- Increased productivity
- Higher product quality
- Greater flexibility
- Lower product cost
- Reduced injury costs

The employee also realizes the actions, which create these employer benefits:

- Improved work environment
- Less fatigue and stress
- Pride in workmanship
- Job security and job opportunity
- Reduced injury risks

Through applied ergonomics, actions and investments designed to improve profits provide significant employee benefits as a by-product with no additional cost.

Commitment

The first critical factor required to gain the numerous economic benefits of applied ergonomics is the same as the nucleus of almost any program, commitment.

Without this driving force, there will always be traps and shortcuts, which dilute the efforts and restrict the outcome of the program. Here are some traditional human factor solutions which on the surface seem ergonomically correct but if implemented alone fall far short of achieving the full potential of benefits available through a complete program.



Proper lifting Technique: Although there may be better ways of lifting than others lift, most experts agree that there really isn't an ideal way to manually lift. Further more if lifting is a repetitive part of the job, regardless of style, the fatigue factor will remain.

Safety Slogans: Many companies put up signs and posters urging employees to work safely. Awareness is important. However, practical solutions to problems are more important. In other words, employees can only work safely if they are provided with the proper tools and environment to do so.

Fit the Right Operator to the Job: It would be an ideal ergonomic approach to assign jobs based on the individual's anatomical or physiological characteristics. For instance, selecting a long-armed employee because the particular job required the worker to reach a distant shelf for parts. If that job grade paid a premium rate, the senior employee with short arms would certainly have something to say about the assignment.

More Rest Periods: Again, it would be a sound ergonomic solution to provide more work breaks for employees who are assigned jobs which cause fatigue. However, this non-productive time allowance is obviously inconsistent with the productivity/profit goals of most production operations.

Each of these concepts provides some degree of benefit but the real benefit potential will not be achieved unless the issues are thoroughly evaluated and fully resolved. For instance, if a job requires lifting, rather than simply showing a lifting film, redesign the operation by lowering the worker, raising the material, reducing the weight of the material or employing a lifting device. Only then will the hazardous potential be eliminated and the opportunity for improved output exist.

Identifying Applications

In general, the opportunities to apply ergonomics are as numerous as the employees who populate our factories and warehouses are. Every worker is characterized by a unique array of physical and mental capabilities. Our opportunity is to insure that all work processes and systems (whether manual or automated) include considerations for the range and limits of these human characteristics in order that we gain maximum utilization of the resource.

The first step in the practical application of ergonomics is to identify the problems or operations lacking adequate consideration of the human factors. This process can generally be accomplished by reviewing existing records and workplace observation.

The most critical records to explore are the company's safety records. Any operation, which has a history of safety problems, is an ideal opportunity to apply ergonomics. Not only are solutions to these circumstances easily justified by accident cost savings but also any operation, which yields repeated injury claims, is virtually guaranteed to be a production bottleneck. Specifically, the origin of repetitive accidents in a work process is usually a lack of human factor considerations. This deficiency is normally caused by inefficient plant layout, improper use of equipment or lack of proper equipment. Conditions which not only result in accidents but costly production inefficiencies.



Although the conclusions may not be quite as obvious as those gained from the accident file, there is a number of other company records which send a clear signal for ergonomic evaluation. Many times, the human factor deficiency indicators available from these files are not readily apparent because the records were kept for another purpose. However, the following symptoms of ergonomic inadequacies can generally be discovered through investigation of typical industry records:

- High absenteeism on a specific job
- High turnover on a specific job
- High disciplinary action on a specific job
- High equipment/tool damage on a specific job
- High rework
- High material waste
- Low output
- Declining output over job shift
- Low product quality
- Declining product quality over job shift

Some of these symptoms can be caused by other factors but the likelihood that ergonomic solutions can correct any of these symptoms is highly probable.

Worker feedback about a task is another type of recorded information, which may or may not be found on file. Whether it comes in the form of complaint or suggestion, it usually can be traced to a human factor problem. Repetitive complaints almost always indicate inefficiency. Analyzing the information and surveying similar jobs for parallel circumstances should produce sufficient data for an ergonomic evaluation.

Workplace observation is the most effective method for identifying opportunities to apply ergonomics. This approach reveals the “hands on” indicators of ergonomic shortcomings. In order to achieve the maximum benefit, this type of examination should be a weighted effort toward the objective of locating improper job demands and workplace elements. Otherwise, there may be a tendency to dismiss many important considerations as acceptable practices. Remember, in the workplace, most factors are a constant for at least 40 hours each week. It is also important to conduct these surveys with individuals trained in human factors engineering or specialists in certain aspects of applied ergonomics. Today, a growing number of suppliers are training their representative to identify ergonomic applications for their products.

There are numerous situations observable in the workplace, which are solid indicators that consideration for human factors is inadequate. Among the most common are:

- Workers maintaining a single posture for extended periods
- Workers absorbing the vibration of their tools
- Workers who are frequently away from their workstation
- Workers who have modified their workstation
- Workers who have modified their tools
- Multiple workers handling the same part



- Controls that are difficult to reach
- Controls that are difficult to read
- Poor lighting
- Poor ventilation
- Poor climate

Additionally, there are many dangerous body motions observed in most plants, which can cause serious injury and reduced productivity. Analyze jobs, which require workers to:

- Bend
- Twist
- Stoop
- Push
- Reach
- Pull
- Stretch
- Walk

Close attention should be paid to all jobs, which involve lifting. Any job that requires repeated lifting of even relatively light loads should be avoided or eliminated. Using workers to lift is both non-productive and dangerous, and it will be only a matter of time before the employee is part of the annual 5 to 10 billion dollar back claim statistic.

Implementation Opportunities

Although ergonomics is a highly technical discipline with a unique vocabulary and vernacular like all other sciences, the most significant requirement to begin implementation is common sense. In any warehousing operation, there are numerous opportunities to put ergonomic solutions to work. Simple modifications that do not require major changes in workflow or jobs. The following are elementary examples of the practical applications that are common to almost any distribution facility:

Platform trucks/dollies: These castered vehicles are being increasingly utilized to implement just in time with its smaller quantities of product.

- Check the handle height to assure that it accommodates the greatest possible range of workforce.
- Inspect the casters for wear. Flat spots require unnecessary operator exertion.
- Review the typical function:
- If workers are constantly bending to load and off load products, use a truck with an elevating platform.
- If the loads are heavy, use larger casters, air bearings or power.
- If the travel route is repetitive, evaluate alternate equipment such as a conveyor.
- If the distance traveled is great, evaluate a layout change.

Order picking: Whether the selected order picking system is “part to man” or “man to part”, a key contributor to the productivity of the system is the worker. Consequently, the quantity and



quality of output will be directly effected by the depth of human factor consideration utilized. In man to part systems insure high worker efficiency by:

- Sequencing picking list to minimize the distance that the worker must travel.
- Utilizing conveyors to minimize walking requirements.
- Reducing picking area size to minimize worker travel requirements.
- Vertically positioning containers and totes to minimize bending even on high rise man ride machines.
- Sizing containers and totes to minimize weights which the worker must handle.
- Designing rack and shelving layout to store high volume stock at waist height and reducing bending, reaching and stretching.
- Utilizing labels, bar codes or signal lights to simplify stock location by the worker.

In part to man systems, improve worker contribution by:

- Presenting stock at a comfortable work height.
- Sizing containers and totes to minimize weights which the worker must handle.
- Vertically positioning containers and totes to minimize bending.
- Designing picking stations to reduce twisting, reaching and stretching.
- Utilizing labels, bar codes or signal lights to simplify stock location by the worker.

Palletizing/De-palletizing the perennial “grunt job” of almost any warehousing operation is building and breaking down pallets. Regardless of the weight of the package being handled, manual palletizing operations are dangerous and inefficient unless the operation is designed to suit the capabilities of the worker. Minimize the risk of injury and improve output by:

- Presenting product at a comfortable work height.
- Presenting product next to pallet or skid to reduce walking and carrying requirements.
- Utilizing vertical positioning devices to allow continuous height adjustment of pallets and skids to assure that each tier is being built at a comfortable work height without the need to bend, stoop and stretch.
 - Utilizing turntables to rotate work area to worker and reducing the need to reach, twist, push and pull.
 - Utilizing hoists or manipulators if the package being handled is heavy or bulky.
 - Automating the process if repetition and volume factors can justify the equipment investment.
 - Utilizing skid turners or pallet rotators if the process requires transfer from pallet to slip sheet, in-house pallet to shipping pallet or if damaged packages (which are usually the bottom) need to be removed.

Again, these are simple examples but due to their obvious nature, they help to make the point that there are opportunities to achieve the benefits of applied ergonomics, which do not require a highly technical understanding of the science. Knowledge of the discipline’ finer complexities is vital to the implementation of a full program but common sense and commitment are sufficient to begin a program.



Summary

Our factories and warehouses appear to have gained a firm grasp on the marketplace survival demand for optimum productivity. Managements are implementing programs to improve planning and scheduling, space utilization, product quality and equipment output. An integral component of each of these innovative concepts and installations continues to be the worker. The ultimate success of our challenge to improve productivity therefore directly correlates to our ability to gain maximum utilization of our human resource. Workers will continue to be a key element in industry. Demographic studies indicate that in the near future demand for labor will exceed supply. Historically, our labor efforts have been directed toward reduction only, with little attention focusing on enhancing labor. We can no longer afford to misunderstand ergonomics to be a one-sided quality of life issue. This misconception allows the acceptance of inefficiencies that drain scarce profit dollars. Human factor consideration is a productivity philosophy, which must be applied in the workplace if optimum productivity is to be achieved.

For further reading:

Industrial Ergonomics: A Practitioners Guide, Industrial Engineering and Management Press, IIE, 1985, David C. Alexander and Babur Mustafa Pulat, Editors.

