

# Factory Ergonomics

A study into the impact of ergonomics on productivity, quality and employee health



# Foreword

Every year more than 7.5 million working days are lost to British industry due to more than one million people being affected by musculoskeletal disorders with poorly designed work areas often cited as a key cause\*.

The cost to the British economy is enormous, circa £5.7 billion per annum\*. And yet, ergonomics, posture, workstation design and their impact on employee health remain far down the list of priorities for industry when a new factory is being designed or a new production line is being commissioned.

On the factory floor, humans come into close contact with machinery, from simple hand tools through to sophisticated machine tools. Ergonomics is the study of this human interaction with the different environments we encounter in our daily lives.

The truth of the matter is ergonomics can have a direct impact on the bottom line. Poor posture, overreaching for tools and inadequate lighting, amongst a host of other issues, can lead to back pain, workplace stress and repetitive strain injury. All of this results in lost time, reduced productivity, poor employee health, low morale and higher costs. What's more, poor ergonomics can have a direct impact on product quality. If an operator on an assembly line is stretching to use a hand tool and a bolt is fastened at an angle, greater stress is placed on these elements, potentially leading to failure and a reputation for inferior product quality.

Unfortunately, despite all the evidence to the contrary, ergonomics in the workplace is still regarded in many quarters as being over-bearing and dictatorial. A reassessment of this position is long overdue. Whilst greater automation can lead to increased efficiency, humans remain the most versatile component in a manufacturing process.

This guide is designed to offer production engineers, and those responsible for employee health in manufacturing environments, an overview of the key factors that must be taken into account when incorporating an ergonomic solution into the workplace.

At the end of the day, if employees are truly our most valuable resource, manufacturers must do everything in their power to keep them fit, healthy and productive.

**Ross Townshend** – Expert in manual production systems at Bosch Rexroth

\*Health and Safety Executive report

## What is ergonomics?

An ergonomic workstation facilitates work and maintains good health. Its aim is to increase motivation and satisfaction, higher performance, efficiency and processing quality, as well as fewer absences due to illness.

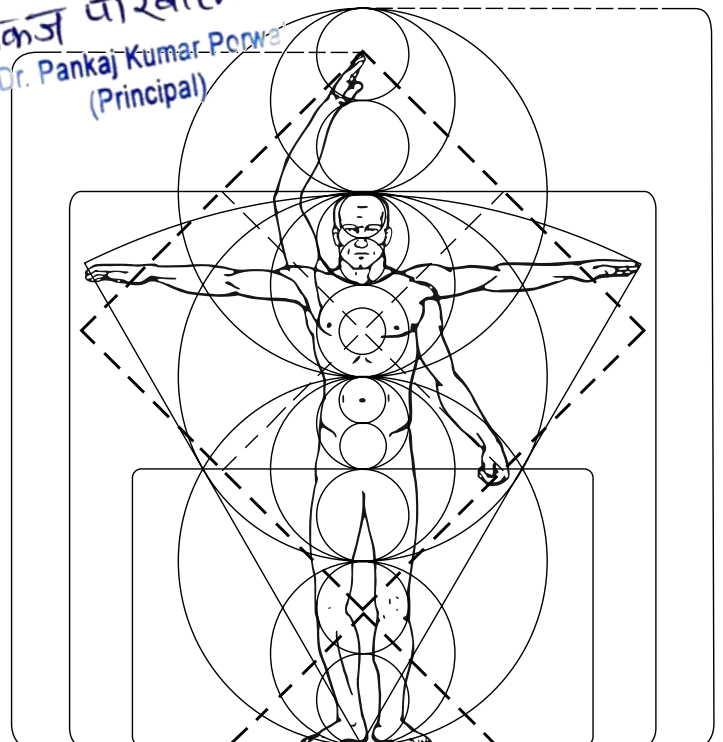
## What is the benefit from ergonomics?

Ergonomics will provide you with valuable benefits in the form of higher productivity, increased efficiency, and a decisive edge over the competition – thus ensuring lasting success for your company.

We can support you with this and provide valuable suggestions. One example is the eight key rules of ergonomics, covering the most essential aspects of EN ISO 6385. This will help you methodically plan and implement ergonomic workstations and flow racks as well as taking employee size, tasks, and lighting into account.

For Techno India NJR Institute of Technology

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# The eight rules of ergonomics for work systems



1. Body height and working height
2. Work area
3. Reach zone
4. Parts presentation
5. Range of vision
6. Lighting
7. Adjustment of work equipment
8. Planning and design tools

# Rule 1: Body height and working height

Manual workstations must accommodate a wide range of body heights to ensure that the largest percentage of the population is covered. Country specific differences and regional requirements must also be taken into account. The most important factors for designing work equipment are the working height, proper sizing of the reach zones and required leg room, as well as definition of the appropriate range of vision. All of these dimensions are derived from “standardised” body height. For example, in Germany, DIN 33 406 must be followed when specifying and designing a workstation.

## Classification of body heights

The body heights of the population can be classified into four groups:

**Group 1:** Smallest woman (only 5% are smaller)

**Group 2:** Average woman and smallest man

**Group 3:** Largest woman and average man

**Group 4:** Largest man (only 5% are larger)

## Definition of the optimum working height

The optimum working height is based on the body height range and the type of activity to be performed. If you take all body heights into consideration, the average optimum working height for average requirements is 1125mm for sit-down/stand-up workstations.

## Definition of the table height

The table height follows from the optimum working height minus the height of the work piece or insertion point. To ensure sufficient leg room for those in body height group 4, we recommend a minimum height of 1000mm for sit down and stand-up workstations. Further criteria that must be taken into account includes:

- ▶ Foot and leg room, depth and adjustment range of the footrest
- ▶ Size and variation of work piece dimensions
- ▶ Occurring forces and weights
- ▶ Changing types of equipment and insert heights
- ▶ Greatly varying vision distances
- ▶ Local specifications (deviating body heights, legal requirements, etc.)
- ▶ Aspects related to methods, safety, and efficiency



## Rexroth's sit-down/stand-up concept for production

The sit-down/stand-up concept developed and recommended by Bosch Rexroth makes it possible to work at the same height when sitting and standing. This largely compensates for different body heights. The concept permits changes in posture, which reduces stress and increases performance. This is not possible with a purely sit-down or stand-up workstation alone.

## Flow rack design

The container weight and type of activity are decisive when designing flow rack systems. The following aspects should also be taken into account for material supply and removal:

- ▶ Total load on the employee during the shift
- ▶ Country-specific requirements and standards

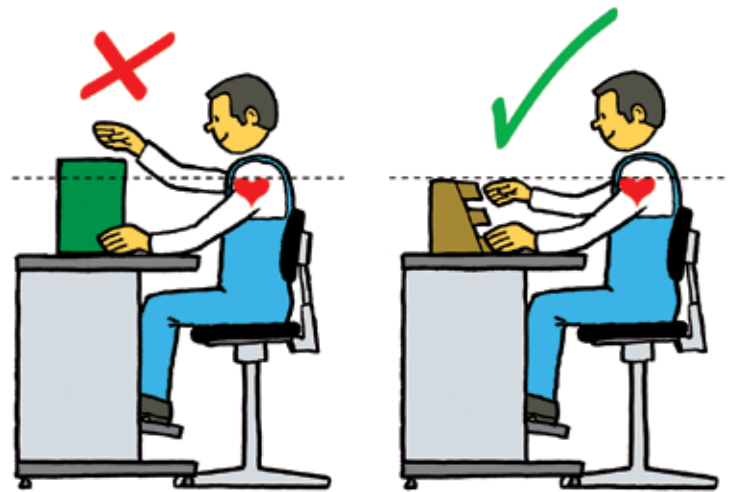
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# Rule 2: Work area

Ergonomic workstations are at the centre of assembly line production. Sit-down/stand-up workstations, as well as material supply containers from Rexroth, provide an optimum basis for work without fatigue and can be adjusted to the needs of the individual employees.

The required activities and work processes are defined based on a specific cycle time. The optimum working method is determined in a method analysis that takes time, ergonomics, and efficiency into account. It's also important to consider any trends towards an aging work force or changing employee performance.

According to our experience, inclusion of all concerned employees from assembly, quality assurance, and logistics, ensures the best results and long-term acceptance of the method and, as a result, acceptance of the workstation system. The work area height should always be between 800mm and 1500mm.



The following rules must be observed:

**Promote dynamic activities:**

Static holding activity inhibits the blood circulation and supply of oxygen to the muscles. This can lead to a drop in performance and processing quality.

**Avoid work above the heart (over 1500mm):**

Otherwise, the blood circulation and supply of oxygen to the muscles is reduced, which leads to a drop in performance. Work that requires bending below 800mm taxes employees disproportionately and should be avoided.

**Allow for varying physical exertion:**

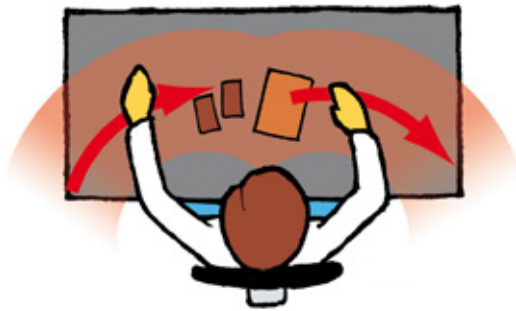
For example, through sit-down/stand-up workstations or job rotation, varying physical exertion reduces stress on the employee and increases performance.

**Minimise exertion:**

For example, through the use of manual roller sections or lifting aids, as well as by selecting lighter weight materials.

# Rule 3: Reach zone

The following rules apply for an ergonomic reach zone design: All containers, equipment, and operating elements must be easily accessible and arranged in the anatomic/physiological range of movement for the employee. Torso rotations and shoulder movements, particularly when under exertion (with weights >1kg), should be avoided whenever possible.



Characterisations of the three reach zones:

## Area A

- ▶ Optimum for working with both hands, as both hands can reach this zone and are within an employee's field of vision
- ▶ For fine motor movements
- ▶ Possible to handle lighter weights and also enables improved inspection and co-ordination activities
- ▶ Pure lower arm movements
- ▶ Smaller muscle groups are in use
- ▶ Area for work piece support, work piece pallet or equipment

## Area B

- ▶ For gross motor movements
- ▶ Area for tools and parts that are often grabbed with one hand
- ▶ Upper and lower arm movements without use of the shoulders and rotation of the torso

## Area C

- ▶ For occasional handling, e.g. of empty containers or transferring parts to the range of movement for the next employee
- ▶ With shoulder and torso movement



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# Rule 4: Parts presentation

All reach distances should be as short as possible to avoid unnecessary movements that add nothing to the value and thus avoid waste. Grab containers and parts containers that are in direct reach of the employee are ideal. The position of these containers should enable a flowing movement that curves upward away from the body when parts are removed.

The following aspects must be taken into consideration for parts supply:

- ▶ Positioning of all grab containers in areas A and B
- ▶ The more frequently a grab container is used, the shorter the reach distance should be
- ▶ Heavy parts should be stored within reach in the lower containers to avoid unnecessary exertion (e.g. caused by lifting and lowering)
- ▶ Bending of the torso below 800mm places a disproportionate strain on the human body
- ▶ Use of geometric and physical features of the parts during parts transfer, e.g. through the use of a slide rail or roller conveyor
- ▶ Arrangement of different-sized containers according to parts geometry, maximum weight, and refill cycle
- ▶ Reduction of time for parts supply and removable by up to 68 percent (MTM – Method of Time Measurement). Employees can concentrate on productive assembly work



# Rule 5: Range of vision

For optimal workstation design, it's important to follow recommendations on ergonomics for vision as well.

You can differentiate between two vision areas:

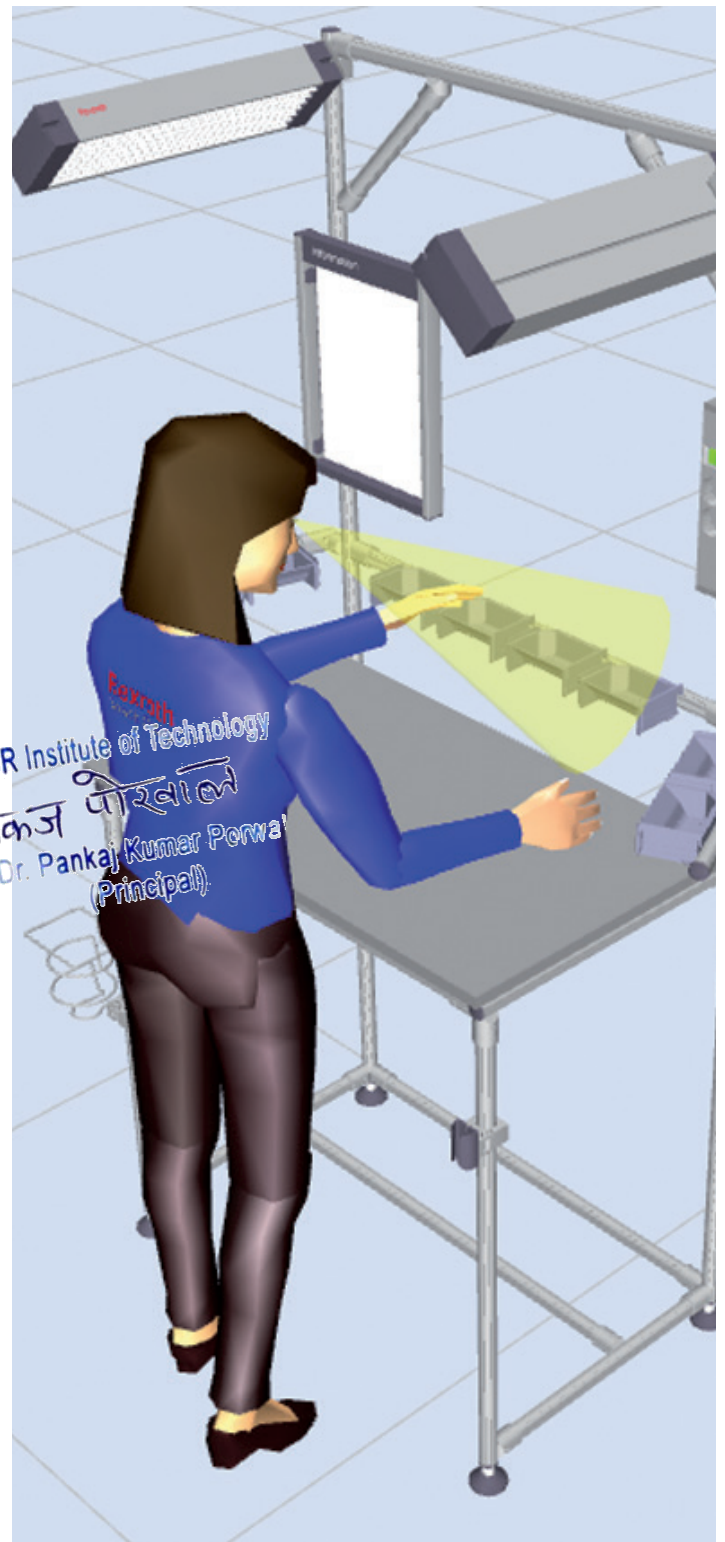
- ▶ In the field of view, several objects can be seen in focus simultaneously without moving the eyes or head. Additional focusing for depth may be required here.
- ▶ In the visual field, objects can be seen by moving the eyes, but not the head. Additional focusing for depth may also be necessary here.

Head movements are required outside these ranges. When standing, the angle of the view is 30 degrees from the horizontal plan and 45 degrees when sitting.

The following aspects must be taken into account during planning:

- ▶ Avoid unnecessary eye and head movements
- ▶ Implementing vision distances that are as identical as possible eliminates refocusing
- ▶ Avoid fastening locations not visible to worker

Complying with these three recommendations facilitates work and increases productivity. Every time you turn your head or change the direction of vision and refocus results in lost time and money. The exact values can be determined via the MTM procedure.





# Rule 6: Lighting



The right light, adapted to an activity at the workstation, is a basic prerequisite for a high efficiency and processing quality.

Optimum lighting prevents premature fatigue, improves concentration and reduces the risk of errors.

Important aspects for planning workstation lighting include:

- ▶ Avoid strong contrasts
- ▶ Avoid glare and reflection

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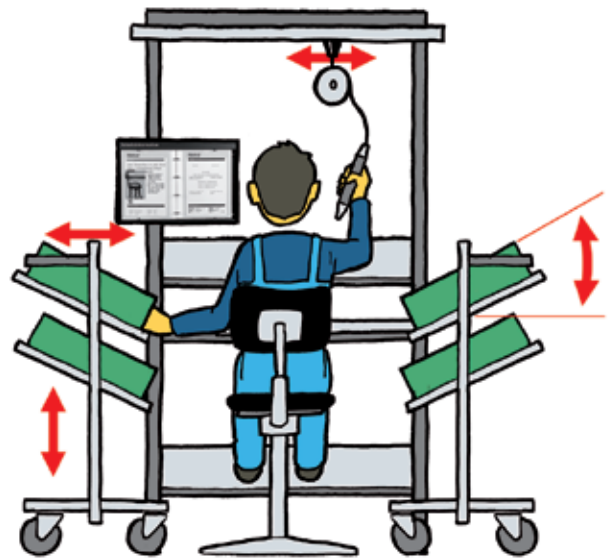
# Rule 7: Adjustment of work equipment

To maintain performance and promote productivity, all work equipment near the workstation must be precisely adjusted to the employee and the activity. All height-adjustable workstations should be adapted to both the product and the worker.

All Rexroth components for equipping workstations can be combined to form a perfectly co-ordinated ergonomic system. Rexroth products offer numerous adjustment options that promote proper posture and reduce fatigue, making ergonomics simple and beneficial.

High performance and productivity require the correct sitting posture: The worker's calves and thighs should form a 90° angle. This also applies to the upper and lower arms, though here the angle may be slightly greater than 90 degrees. The lumbar support should permit individual adjustments to the body height and optimum support point of each user.

Correct adjustment of the table, chair, footrest, and grab containers, as well as the position of tools and material shuttles, minimises movements, reducing physical exertion and employee absences. Rexroth swivel work chairs feature an ergonomic seat and backrest design. The permanent contact backrest also adapts itself to the upper body movements of the user, thus supporting the back in every position.



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## Important considerations:

- ▶ When adjusting chairs and footrests, make sure that thighs and calves form a right angle
- ▶ Information boards should be hung at the eye level to avoid unnecessary head movements
- ▶ The angle of the shelves for material supply should be adjusted to create short, direct reach distances
- ▶ Use lifting aids to supply heavy parts
- ▶ Monitor brackets and tool shelves can be adjusted to any height
- ▶ With height-adjustable workstations, the optimum working height can be adjusted according to the size of the person or product information on how to adjust the work equipment can be provided on information boards

If processes, products, or employees change frequently, check the work equipment regularly to ensure proper ergonomic adjustment.

# Rule 8: Planning and design tools



Planning templates help you to easily generate sketches or check whether CAD printouts are ergonomic. You can also take advantage of MTpro, planning software for assembly systems. Rexroth guides you through all the necessary steps to select, configure, and order products.

#### **MTpro offers:**

- ▶ Savings in time
- ▶ Flexibility
- ▶ Error prevention
- ▶ Clarity
- ▶ Standardisation

Multiple workstations are linked to form a production line that follows lean production principles. This highly user-friendly software accelerates and simplifies planning of application-specific workstations, flow racks, and material shuttles.