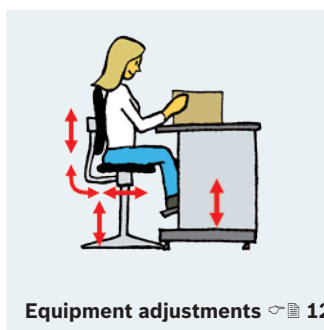
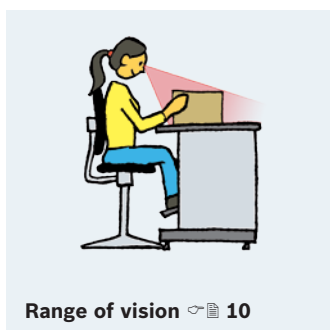
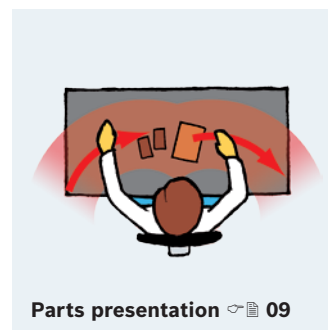
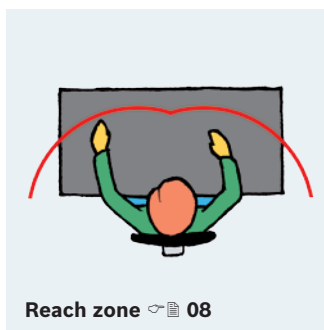
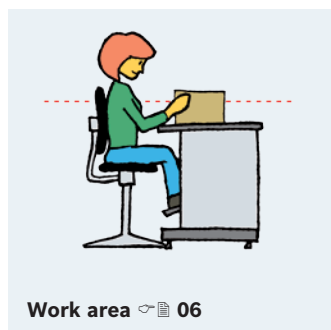
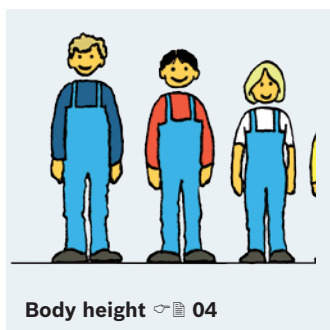


Ergonomics Guidebook for Manual Production Systems

3.0



The eight rules of ergonomics for work systems



Benefit from ergonomics

Use the advantages of an ergonomically designed workstation system. We can support you with this and provide valuable suggestions. One example is this ergonomics guidebook, which contains the eight key rules of ergonomics, covering the most essential aspects of EN ISO 6385.

This guidebook is a reference to help you methodically plan and implement ergonomic workstations and flow racks. Among other things, it takes employee size, tasks, and lighting into account.



Ergonomics – For motivated employees, higher productivity, and better quality

An ergonomic workstation facilitates work and maintains good employee health. The results: Increased motivation and satisfaction, higher performance, efficiency, and processing quality, as well as fewer absences due to illness. The bottom line: Ergonomics 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.

- 04 Body height and working height
- 06 Work area
- 08 Reach zone
- 09 Parts presentation
- 10 Range of vision
- 11 Lighting
- 12 Adjustment of work equipment
- 14 Planning and design tools



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. For example, in Germany, DIN33406 must be followed when specifying and designing a workstation. 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 a “standardized” body height.

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)

Grouping of body heights in Germany:

In accordance with DIN 33402 and DIN EN ISO 7250



Men:	■ 1650 mm	□ 1750 mm	■ 1855 mm
Women:	■ 1535 mm	■ 1625 mm	□ 1720 mm
■ Group 1	■ Group 2	□ Group 3	■ Group 4

Definition of the optimum working height

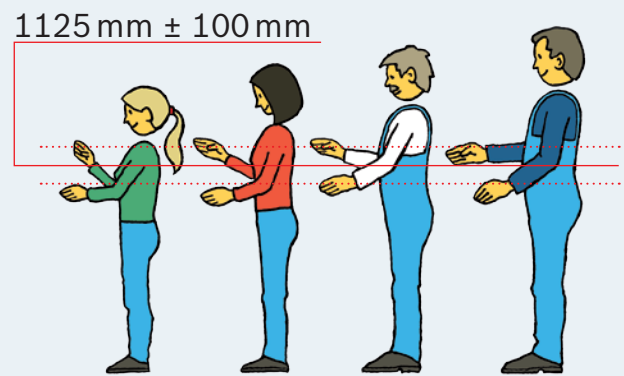
The optimum working height is based on the body height range and the type of activity to be performed (see table). If you take all body heights into consideration, the average optimum working height for average requirements is 1125 mm for sit-down/stand-up workstations.

Work contents	Working heights in mm			
	Group 1	Group 2	Group 3	Group 4
High requirements for Visual inspection Fine motor skills	1100	1200	1250	1350
Medium requirements for Visual inspection Fine motor skills	1000	1100	1150	1250
Low requirements for Visual inspection High requirements for Elbow-room	900	1000	1050	1150

Average optimum working height = 1125

Average optimum working height:

For all four population groups



Group 1 1535 mm	Group 2 1640 mm	Group 3 1740 mm	Group 4 1855 mm
--------------------	--------------------	--------------------	--------------------

Definition of the table height

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

- ▶ Foot and leg room, depth and adjustment range of the footrest
- ▶ Size and variation of workpiece 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 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.

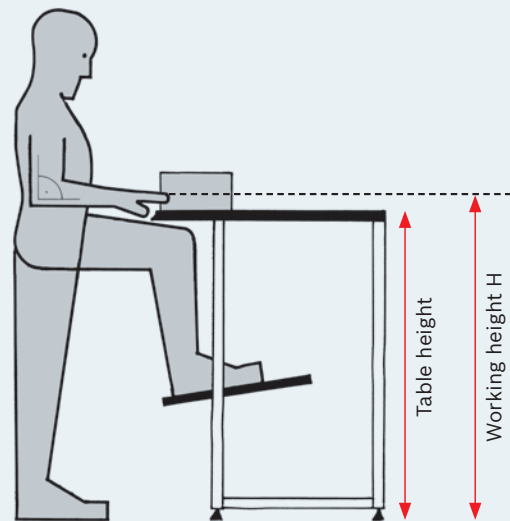
Flow rack design

The container weight and type of activity are decisive when designing flow rack systems. We recommend the arrangement shown in the figure. 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

Relevant parameters:

For defining the table height
for a sit-down/stand-up workstation



Recommended working heights:

A: Higher container weight, B: Lower container weight
C: Occasional handling



Work area

The required activities and work process are defined based on a specified 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, for example 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 800 mm and 1500 mm. Here, the following rules must be observed:

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

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 800 mm) taxes employees disproportionately and should be avoided.

Above the heart

Work areas above the heart: Decreased blood circulation reduces performance



► **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.

► **Allow for varying physical exertion:**

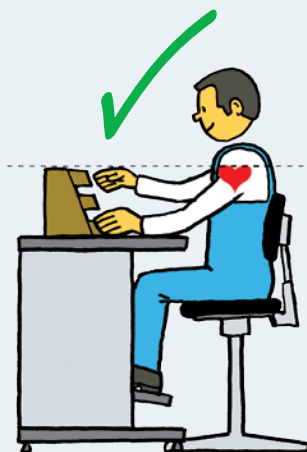
For example, through sit-down/stand-up workstations or job rotation. Varying physical exertion reduces stress on the employee and increases performance.

► **Minimize exertion:**

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

Below the heart

Work areas below the heart: A good supply of oxygen to the muscles and increased performance





Ergonomic workstations are at the center 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 individual employees.



At rest



Blood requirement Blood supply



Static activity

Static activities, such as holding an object continuously, reduce the blood and oxygen supply



Blood requirement Blood supply

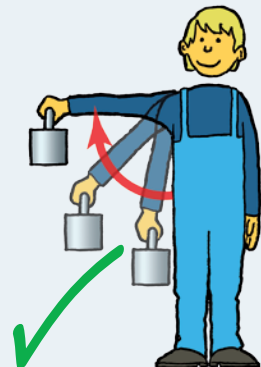


Dynamic activity

A sufficient oxygen supply is ensured with dynamic activities



Blood requirement Blood supply



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 ≥ 1 kg), should be avoided whenever possible.

Characterization of the three reach zones

Area A

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

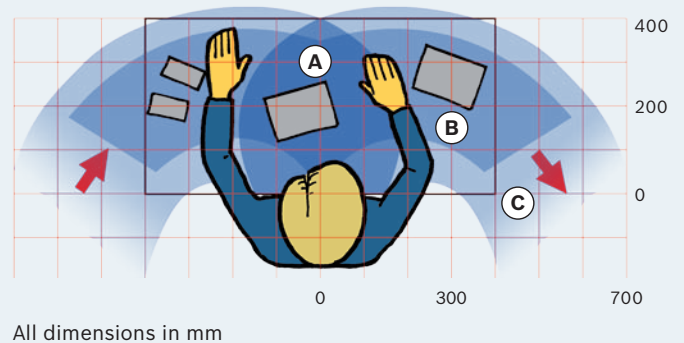
Area B

- ▶ 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

Reach zone for the smallest woman (body height group 1)



You can differentiate between three reach zones at the workstation:

- ▶ **Area A:** Center of work, two-handed zone
- ▶ **Area B:** Large reach zone
- ▶ **Area C:** Extended one-hand zone

Sit-down/stand-up workstation:

Parts transfer via Eco-Flow roller sections



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 removal by up to 68% (MTM – Method of Time Measurement). Employees can concentrate on productive assembly work

▲ **Let our case lifters help you to keep sick days down**

▶ **Exchangeable material supply shuttles reduce setup times**



Range of vision

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

You can differentiate between two vision areas:

- ▶ In the field of view (red vision area), 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 (light gray vision area), 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 view is 30° from the horizontal plane and 45° when sitting.

Definition of the assembly station and parts supply

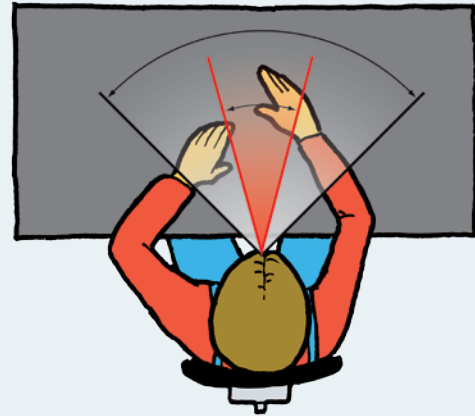
The following aspects must be taken into account during planning:

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

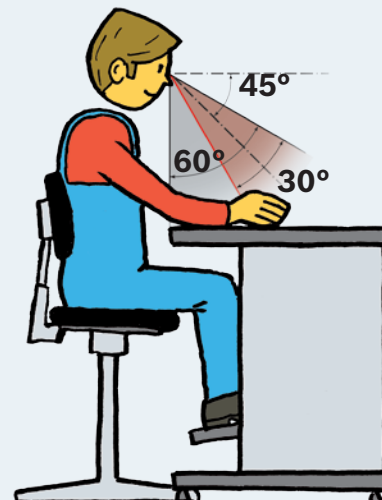
Range of vision from above:

The field of view is red and the visual field is light gray.



Range of vision from the side:

The field of view is red and the visual field is light gray.



Lighting

The right light, adapted to the activity at the workstation, is a basic prerequisite for 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
- ▶ DIN EN12464 and the table below contain the required mid-range lighting intensities

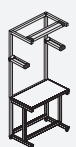
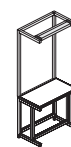
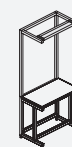
Lighting of test workstations that is free of shadows, flickering, and glare (see figure)



The right Rexroth system light for every task

Calculation example for work top lighting

Rexroth SL 78 (nominal luminance intensity) 681 lux
 (lamp-to-table distance = 1.25 m)
 + ambient lighting 300 lux
 = work top luminance intensity of 800 lux



Tasks	Required luminance intensity (lux)	Rexroth SL 36 Duo	Rexroth SL 72 / economic	Rexroth SL 78	Rexroth SL 78 + SL 36 Duo
Rough and average machine and assembly tasks such as turning, milling, and planing	300	■ ¹⁾	■ ¹⁾		
Fine machine tasks with permissible deviations	500	■ ¹⁾	■ ¹⁾	■ ¹⁾	
Fine assembly tasks, e.g. telephones, winding medium-sized coils, marking, inspection, and measuring stations	750	■■■■ ¹⁾	■■■■ ¹⁾	■ ¹⁾	■ ¹⁾
Very fine assembly, e.g. measuring instruments, assembly of tools, gauges, and equipment, precision mechanics and micromechanics	1000			■■■■ ¹⁾	■ ¹⁾
Assembly, inspection, and adjustment of extremely small parts	1500				■■■■ ¹⁾

¹⁾ Distance between the table top and light: 1.25 m

■ Lamp luminance intensity sufficient for task

■■■■ Lamp luminance intensity + ambient light (300 lux) sufficient for task

Adjustment of work equipment

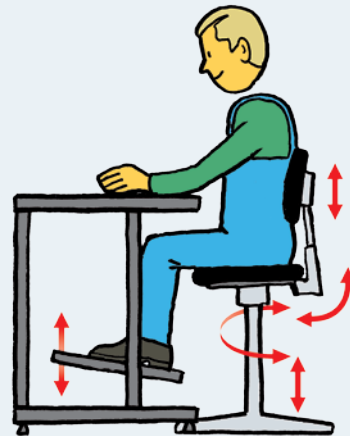
To maintain performance and promote productivity, all work equipment near the workstation must be precisely adjusted to the employee and the activity.

All of the Rexroth components for equipping workstations can be combined to form a perfectly coordinated ergonomic system. Rexroth products offer numerous adjustment options that promote proper posture and reduce fatigue. We make ergonomics simple and you benefit.

High performance and productivity require the right 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°. 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, minimizes movements, thus 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.

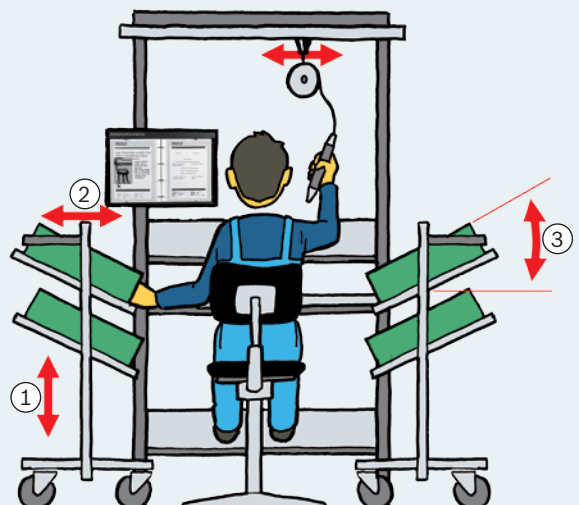
Adjustment of the workstation to the employee



Adjustment of material shuttles to the employee

Adjust as needed:

1 = height, 2 = depth, 3 = angle





A few important considerations

- ▶ When adjusting the chair and footrest, make sure that the thighs and calves form a right angle
- ▶ Information boards should be hung at 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 via the profile slot
- ▶ 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.

Separate adjustment of material feed height and working height:

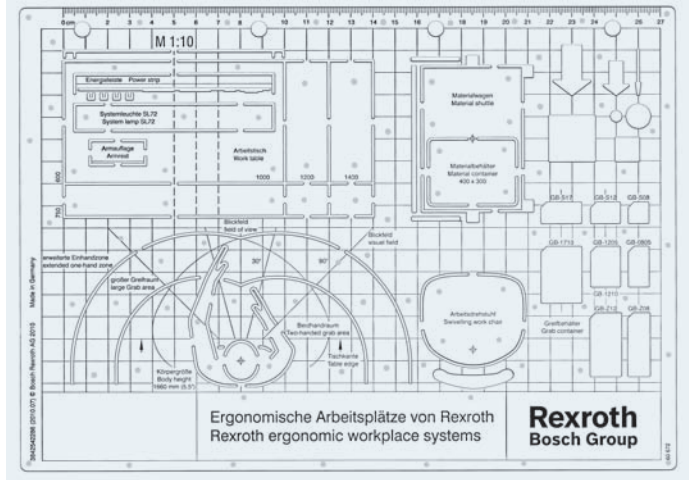
Height-adjustable workstations can be adapted to both the product and the worker.

Planning and design tools

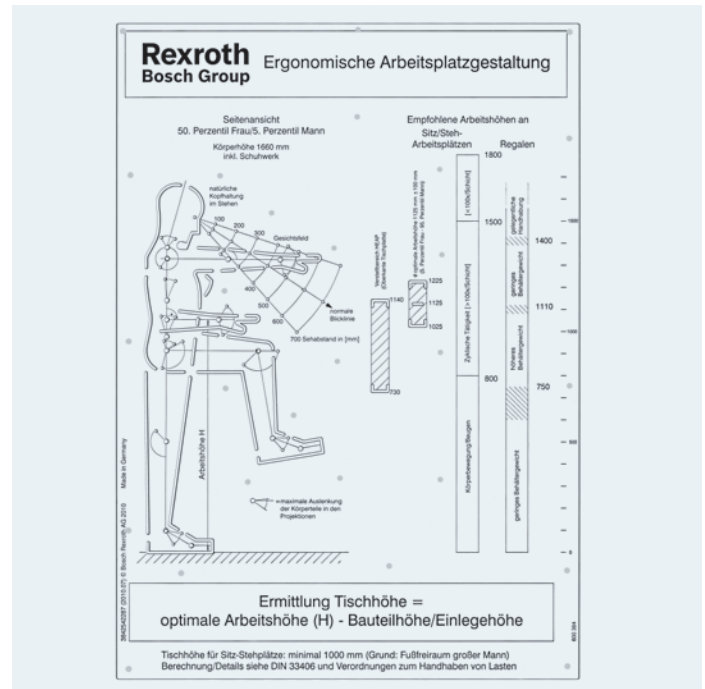
Planning templates help you to easily generate sketches or check whether CAD printouts are ergonomic. You can also take advantage of *MTpro*, our planning software for assembly systems. Rexroth guides you through all the necessary steps to select, configure, and order products.

Ergonomics templates

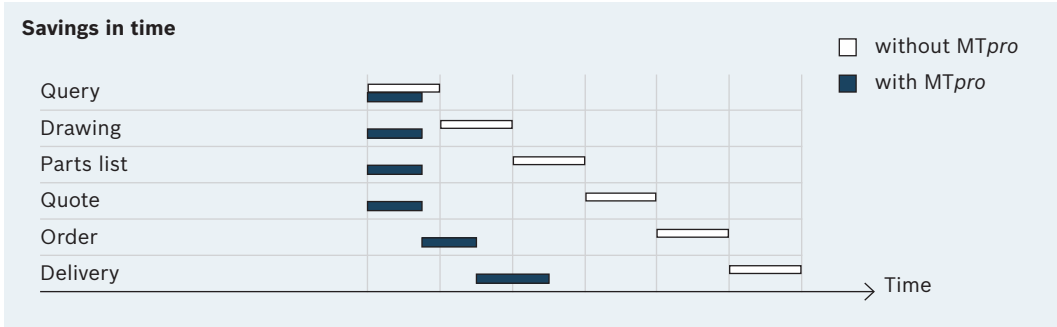
For the average woman or smallest man (group 2).
Scale 1:10. The two figures are not shown in original size!



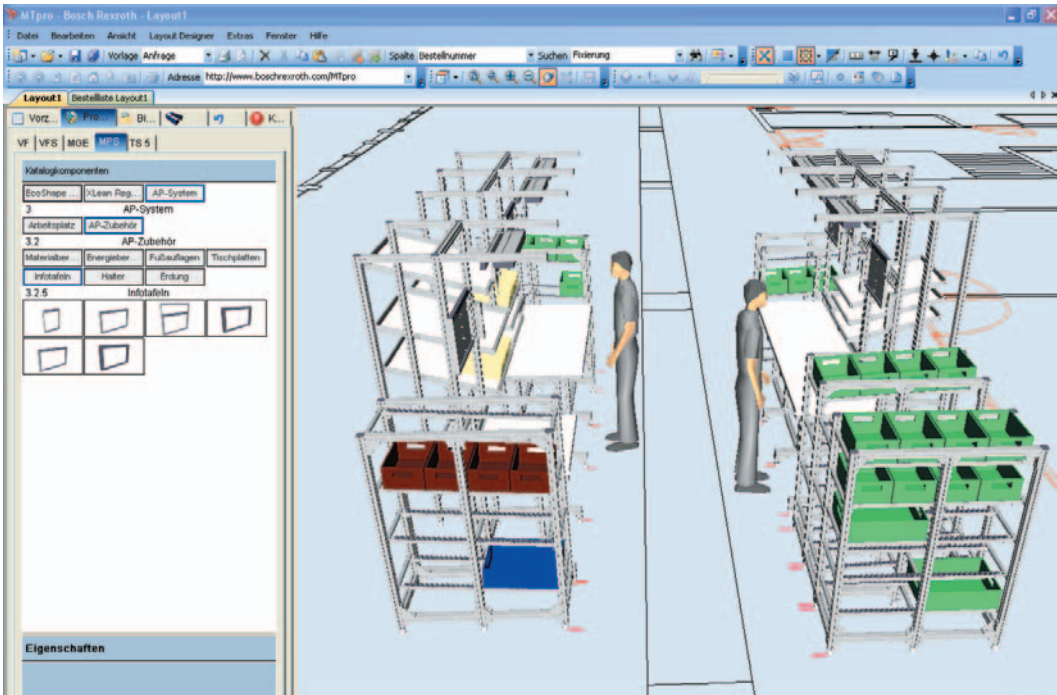
3 842 542 286



3 842 542 287



- ◀ **MTpro offers:**
- Savings in time
 - Flexibility
 - Error prevention
 - Clarity
 - Standardization



- ◀ **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. Complete orders can be placed in no time at all. The data can also be easily imported into your CAD or VR (virtual reality) environment via a CAD interface.

Bosch Rexroth AG

Postfach 30 02 07
D-70442 Stuttgart, Germany
Tel.: +49 711 811-30698
Fax: +49 711 811-30364
www.boschrexroth.com

You can find local contact information at:

www.boschrexroth.com/addresses