HSE

Health and Safety Executive

Ergonomic Considerations for Designing and Selecting Conveyor Belt Systems

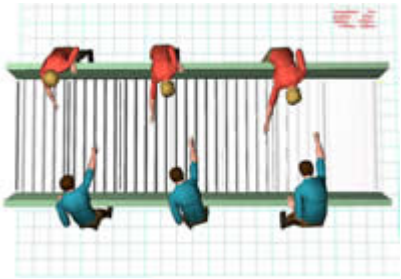
Guidance produced by HSE, European and International Standards, and Ergonomics literature contains information on how to design workstations in relation to human body dimensions. This information is used here to provide guidance for designing and assessing conveyor belt workstations, for both seated and standing operators.

Ergonomic Considerations for Designing and Selecting Conveyor Belt Systems: Background

Conveyor belts are used in many industries to transport goods and materials between stages of a process. Using conveyor systems is a good way to reduce the risks of musculoskeletal injury in tasks or processes that involve manual handling, as they reduce the need for repetitive lifting and carrying.

However, despite their benefits, conveyor belt workstations can contribute to the development of musculoskeletal disorders (MSD's) if they are not properly designed with the task and users in mind.

MSD's can develop when workers adopt awkward and uncomfortable postures for long periods whilst working. Leaning, stooping, twisting, and reaching are all examples of postures that can lead to musculoskeletal injury.



The design of some conveyor systems can produce these postures by having the belt positioned too low or too high for the operator, by being too wide so the operator has to reach excessively to pick objects from the belt, by not having adequate clearance for feet at floor level so the operator has to lean forwards to work, and by having features such as sills and skirts that can obstruct the operator's access to the belt.

Organisational issues can also influence the incidence and development of MSD's. The pace of work, opportunities for rest and recovery, and the length of time that the operator performs the task are all important factors to consider when assessing the risk of musculoskeletal injury in a task performed at a conveyor.

Conveyor systems may be designed to transport a certain volume of material in bulk per hour, or for a manufacturing process where each object on the belt is handled sequentially.

The amount of material transported on the conveyor, its size, and the amount of work performed on it influences the width of the belt.

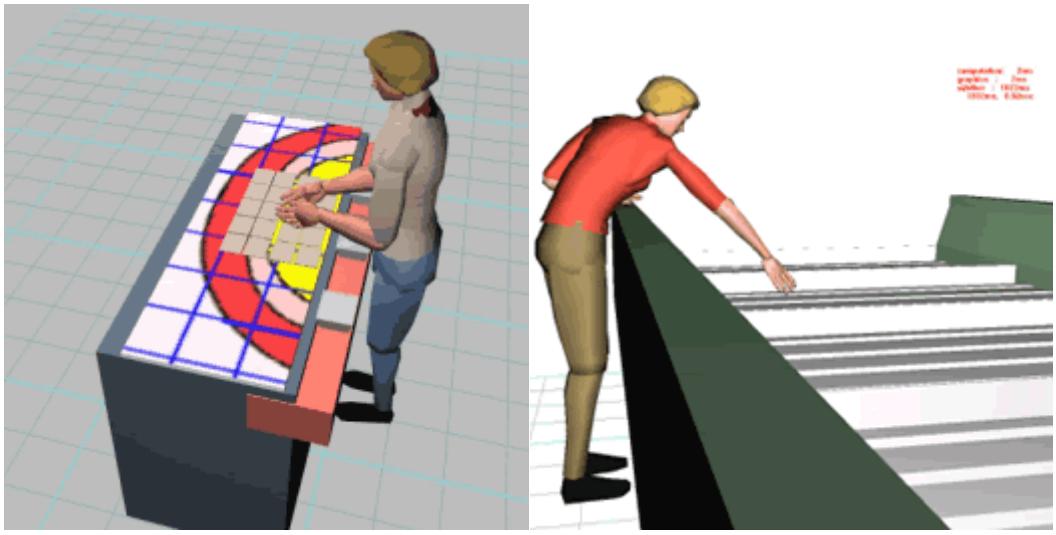
The height of the material, and how it is to be handled or processed influences the height of the belt.

The height of the hands whilst working influences comfort and risk of musculoskeletal injury.

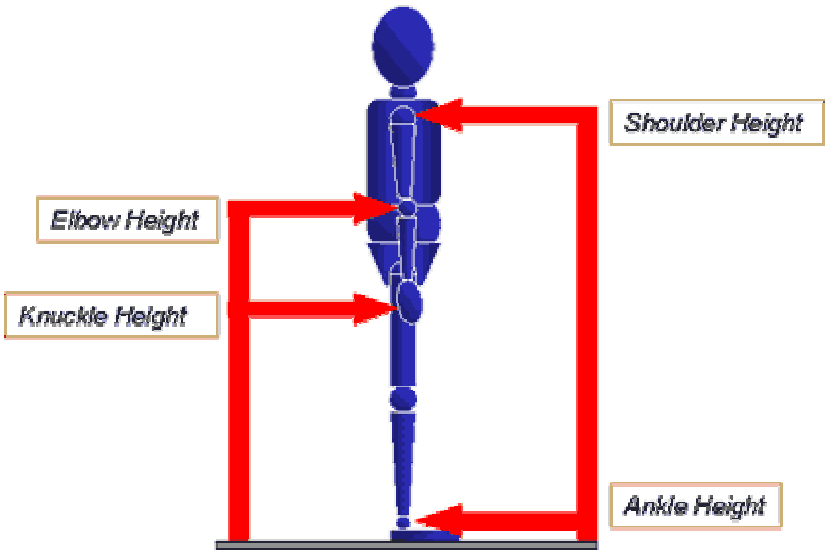
Because of this, the physical aspects of the conveyor workstation that are most important when assessing the risk of MSD's are work surface height and reach distance. The working height provides information about the suitability of the work surface height:

The work surface height is the height of the conveyor belt from floor level
Reach distance is the distance in front of and to the side of the body over which the operator has to reach to perform the task

The working height is the height at which the hands are normally held to perform work on objects on the conveyor



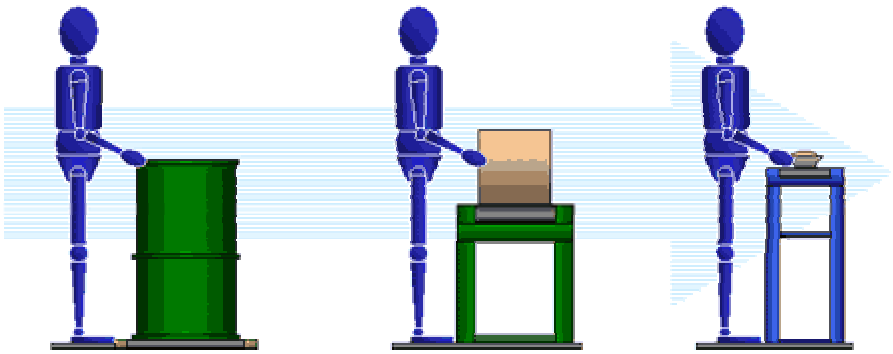
Reference points on the body are often used in place of absolute measurements when considering work surface height and working height. This is because the preferred work surface height for an individual is usually in relation to their own stature. Common reference points used in HSE guidance and Ergonomics literature are shown below:



These heights differ considerably between individuals in the working population, and because of this, one fixed work surface height cannot be completely suitable for everyone.

Ergonomic Considerations for Designing and Selecting Conveyor Belt Systems: Work Surface Height

Object size can differ considerably at different stages of a process, so varying the conveyor belt height relative to the size of the object at these various stages can help operators to maintain a comfortable working posture:

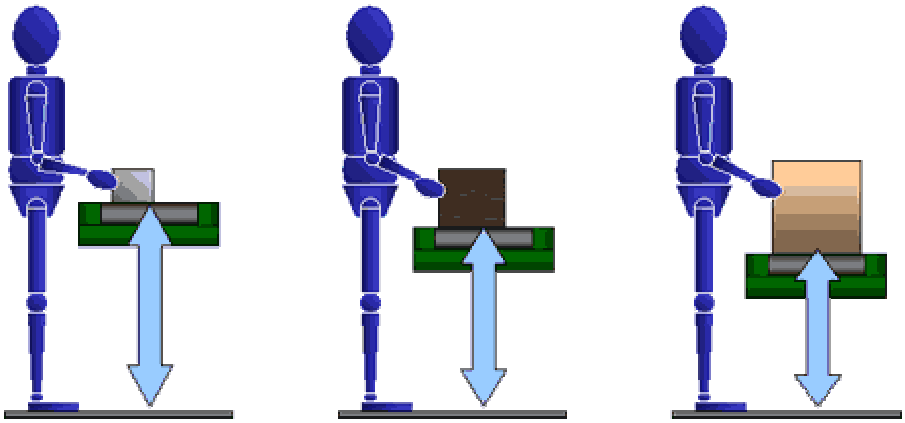


However, within each process stage the belt height is considered to be fixed so objects can be transported without disturbance. This means that the work surface height must be set at an appropriate fixed height for the operators according to the size and weight of the material carried on it.

From a design standpoint it is more straightforward to set a work surface height to accommodate taller members of the working population, and provide adjustable platforms for shorter operators to stand on rather than setting a lower working surface height that could force taller operators to stoop whilst working.

It is important that platforms provided for shorter operators do not create a tripping hazard. Platforms should be stable and clearly marked with enough room for operators to move their feet.

The most suitable work surface height changes with different task requirements. Heavier tasks performed on larger objects require a lower work surface than light, higher precision tasks performed on smaller objects e.g.

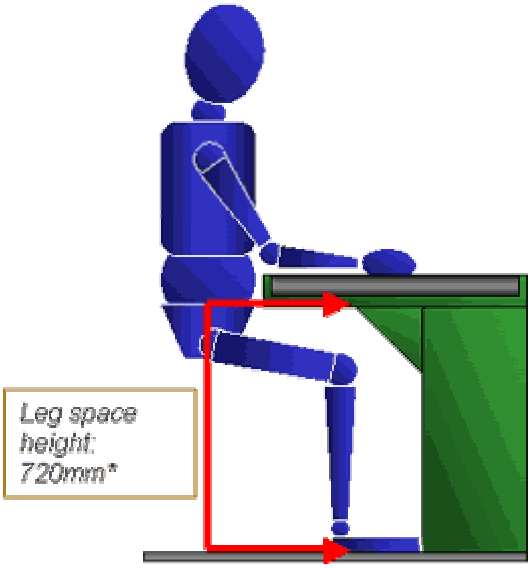


To comfortably work whilst standing, without holding the arms raised, the preferred work surface height for most tasks is set below elbow height. A fixed work surface height for standing workstations 1075mm from floor level* is generally suitable for tasks where the arms need to move freely, such as in belt picking operations, or for light assembly tasks.

This work surface height accommodates the tallest members of the adult working population. Other conveyor operators may require platforms up to 265mm* high to stand on to achieve a comfortable working posture.

This guideline work surface height should be reduced if handling the objects on the conveyor belt requires the arms to be held raised above elbow height whilst working (working height is too high).

The principles of setting a suitable work surface height below elbow height for standing workstations also apply to seated workstations, but with the added need to accommodate the operator's legs comfortably beneath the work surface.



Working whilst seated helps to prevent the fatigue that can contribute to musculoskeletal injury. However, seated working is best suited to low-force tasks, such as belt picking of small to medium sized items, as strength capability whilst seated is lower than when standing.

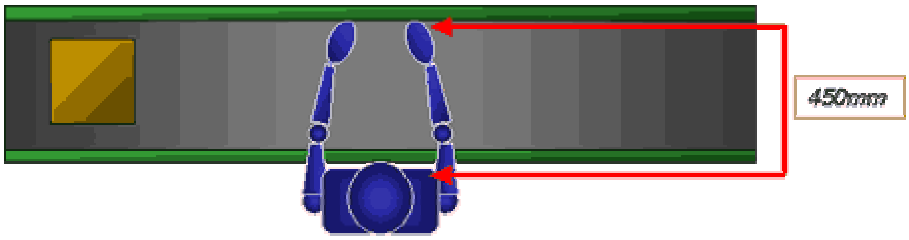
A fixed work surface height for seated workstations up to 780mm from floor level is generally suitable for light belt picking and assembly tasks. This accommodates taller operators, so other members of the working population would need to raise their seat height to achieve a comfortable working posture. Any operator who cannot easily place their feet flat on the floor when the seat is adjusted to the correct working height should be provided with a suitable footrest.

To ensure that a comfortable work surface height at a seated workstation also offers adequate thigh clearance beneath the conveyor belt, the conveyor mechanism must be made as thin as possible. With a minimum leg height clearance under the conveyor of 720mm, the height of the conveyor mechanism would need to be within 60mm to not exceed a work surface height of 780mm. The image below shows a conveyor with a thickness of 35mm.

* ISO 14738 (2002) Anthropometric requirements for the design of workstations at machinery.

Ergonomic Considerations for Designing and Selecting Conveyor Belt Systems: Reach distance

Zones of repetitive reaching on the conveyor should lie within 450mm of the front of the operator's body* to help control the risk of musculoskeletal injury from prolonged and repetitive forwards reaching.

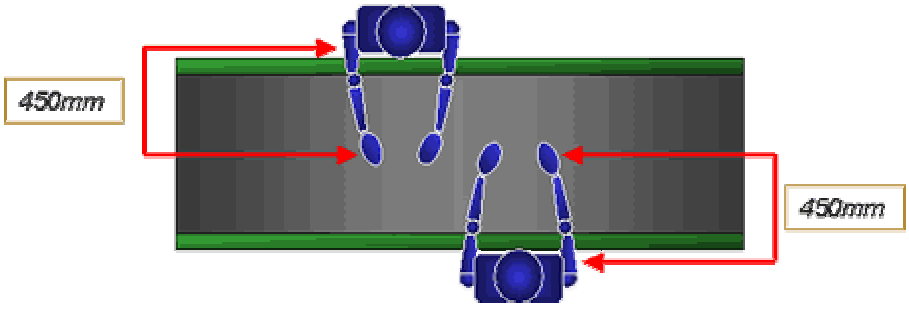


How this guideline affects the width of the conveyor belt depends on the objects being transported:

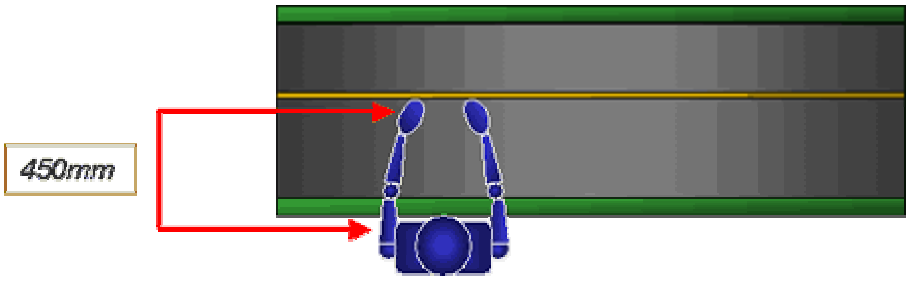
- If numerous items are being picked from the conveyor belt, then the zone of repetitive reaching encompasses the whole conveyor width, and as such the width of the belt should not exceed the 450mm guideline if it only used by a single operator as shown above.
- If the objects being transported are consistently large and take up most of the space on the conveyor belt, the zone of repetitive reaching might not extend to the far area of the conveyor because the objects can be grasped at mid-depth. Here, a wider conveyor could be acceptable providing that the reach distance to adequately handle the object was within 450mm of the front of the operator's body.

Sills, chutes, goods trays, and other features of the workstation can increase the distance between the front of the body and objects on the conveyor belt. It is crucial to take these items into consideration and reduce the reach distance to the far edge of the conveyor accordingly.

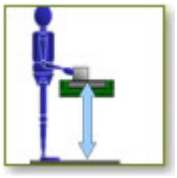
Where operators work on both sides of the conveyor, as is commonly found in belt picking operations, the width of the belt should be such that the central portion of the conveyor is within the 450mm acceptable zone of repetitive reach from operators at either side. This limits the overall width of such a conveyor table to 900mm.



A removable guide placed in the centre of the conveyor can bring reach distances within the guideline limit if the operation shifts from operators working on each side of the conveyor to temporary single-sided working, as shown below.



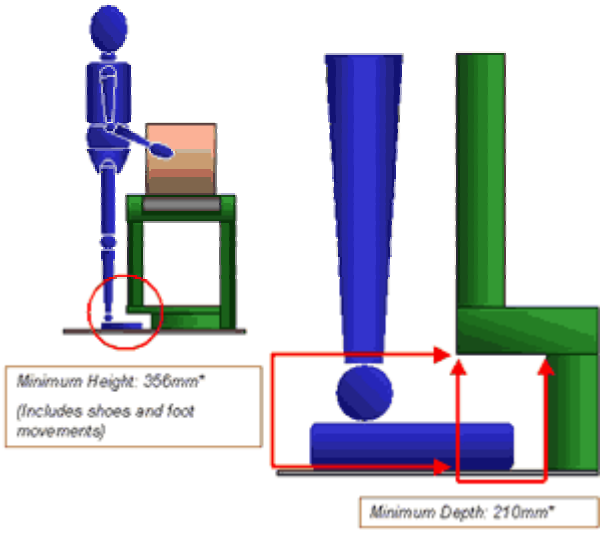
- HSE (2002) Upper Limb Disorders in the Workplace.



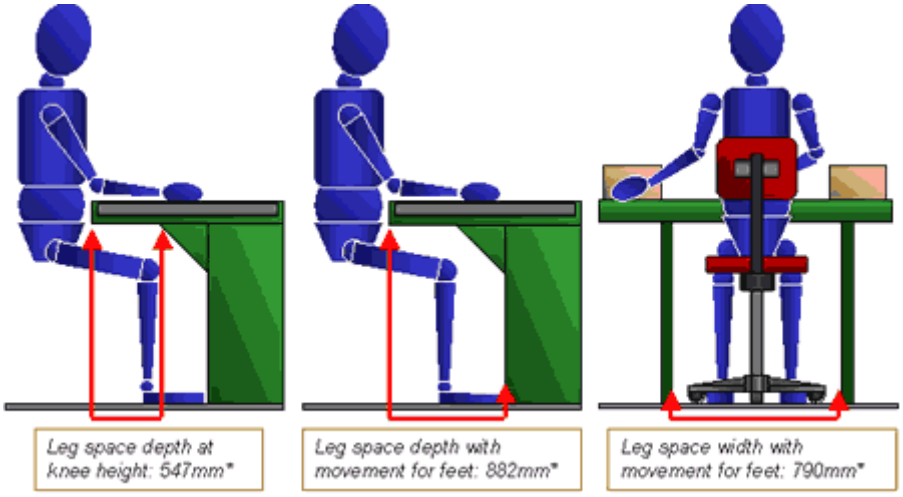
Ergonomic Considerations for Designing and Selecting Conveyor Belt Systems: Foot and leg clearance

Providing adequate clearance at the base of the conveyor for the operator's feet allows them to stand closer to the objects on the belt. This helps to prevent strain on the muscles of the back and neck from holding a stooping posture whilst working.

ISO 14738* gives foot clearance data for standing workstations:



Providing adequate space for the legs and feet to move around underneath the conveyor helps to prevent operators from adopting awkward forward leaning postures that put strain on the muscles of the back and upper body.



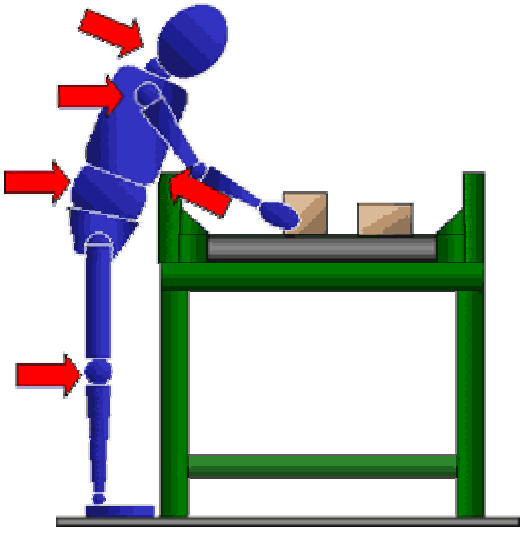
Adjustable footstools up to 165mm* high may be necessary to provide adequate support for the feet where operators need to raise their seat to achieve a comfortable working surface height at the conveyor.

- ISO 14738 (2002) Anthropometric requirements for the design of workstations at machinery.

Ergonomic Considerations for Designing and Selecting Conveyor Belt Systems: Sills

High sills are found on some conveyors and inclined conveyor systems to keep material from falling off the sides of the belt.

Working at conveyors with high sills can force operators to lean over the sill to handle objects on the belt, particularly if the sills are high, which increases the reach distance to the conveyor belt. Working for an extended period in this posture places strain on the postural muscles of the back and the muscles in the neck to hold the trunk and head forwards whilst the arms reach out in front of the body to grasp objects on the belt.



Leaning against the sill to provide support for the upper body whilst working at the conveyor creates localised compression on the soft tissues at the front of the trunk that can quickly become uncomfortable, particularly where the conveyer edge is right-angled. Operators may try to improvise padding on the sill, using bubble wrap or rags for example, to make leaning against it more comfortable. This is a strong indicator that the workstation needs assessment, as operators may be supporting their body weight on the conveyor edge to repetitively grasp objects at the limit of their reach.

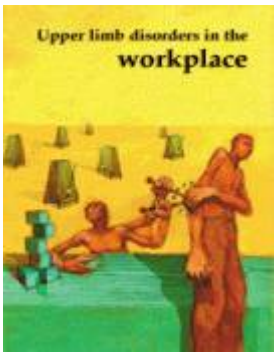
Reducing the height of sills at workstation sites along the conveyor can help to reduce this problem. Material can be prevented from falling off the conveyor when an operator is not present at the workstation by fitting a hinged section to each ‘cut out’ area of the sill.

Rounded-over edges will make occasional leaning against the conveyor to relieve the legs more comfortable.

Ergonomic Considerations for Designing and Selecting Conveyor Belt Systems: Organisational Factors

The incidence of musculoskeletal injury is not always related to the dimensions of the workstation. Organisational and psychosocial factors also play an important role and should be considered when making an assessment of a conveyor-based task.

- The speed of the conveyor is important to consider as it controls the pace of the work and may not be under the operator's control. Struggling to keep up with a pace of work that is set too high can increase the risk of musculoskeletal injury through fatigue, and can be highly stressful for the operator. In some instances, conveyor speeds greater than 10 metres per minute can lead to motion sickness-like symptoms in operators working perpendicular to the belt (Helander 1995).
- Breakdowns further up the conveyor may result in the workstation filling up with material. Areas on the conveyor where surplus material can accumulate in the event of a breakdown can help to regulate the workload of the operator when the system is repaired. A conveyor that is accessible from both sides allows extra operators to help clear a build up of material.
- Conveyor work can place a heavy demand on one side of the body as one is used for reaching and grasping objects as they move past the operator. Working on inclined conveyors also introduces problems as only a small portion of the conveyor is ever at a suitable working height - the rest of the conveyor is either to high or too low to reach without leaning against the conveyor edge or sill, or reaching above elbow height to grasp items on the belt. Periodically working on the other side of the conveyor helps to balance the workload between the two arms. A formal system of job rotation can also help operators to use different groups of muscles and give the muscle groups used for conveyor working a chance to rest. HSE publication HSG60 Upper Limb Disorders in the Workplace (pictured) gives more detailed information and provides a risk assessment filter that is useful for identifying problems with a workstation, task, and system of work.



Where adjustable seating and footrests are used, it is important that operators are informed of how to make adjustments to them.

Ergonomic Considerations for Designing and Selecting Conveyor Belt Systems: Further information

Dul, J. & Weerdmeester, B. (2001) Ergonomics for Beginners, A Quick Reference Guide. 2nd Edition. Taylor & Francis, London.

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Helander, M (1995) A Guide to the Ergonomics of Manufacturing. Taylor & Francis, London.

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Pheasant, S. (1986) Bodyspace: Anthropometry, Ergonomics, and Design. Taylor & Francis, London.

McCormick, E.J & Sanders, M.S. (1983) Human Factors in Engineering and Design, Fifth Edition. McGraw-Hill, London.

Further information on musculoskeletal disorders can be found on the HSE website at: http://www.hse.gov.uk/msd and http://www.hse.gov.uk/msd/backpain.