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Stairways and platforms

Guidelines on requirements and rules



CONTENTS

How this guide can help	02
Introduction	03
Stairways	04
Terms and definitions	04
The basic dimension for all stairways	06
Safety and comfort	08
Guard-rails and hand-rails	09
Safety requirements	11
Traffic loads	13
The typology of stairways	14
Platforms, working platforms and walkways	15
Terms and definitions	15
Safety requirements	16
Hand, knee and foot-rails	19
Inspection, use and maintenance	20

How this guide can help

Stairways are subject to a wide and complex range of safety rules. Unfortunately, not everyone can get access to these rules without having to pay for the privilege and the documents themselves are often written in unintelligible jargon. In fact, it is often very difficult to tell which requirements are relevant to which applications. We have therefore stripped the rules down to the most important information and translated it into language that is easier to understand. These guidelines provide an insight into the key rules that apply when designing and building stairways and platforms in a production environment.

Applicable standards

EN ISO 14122 - 2 Permanent means of access to machinery - Part 2: Working platforms and walkways

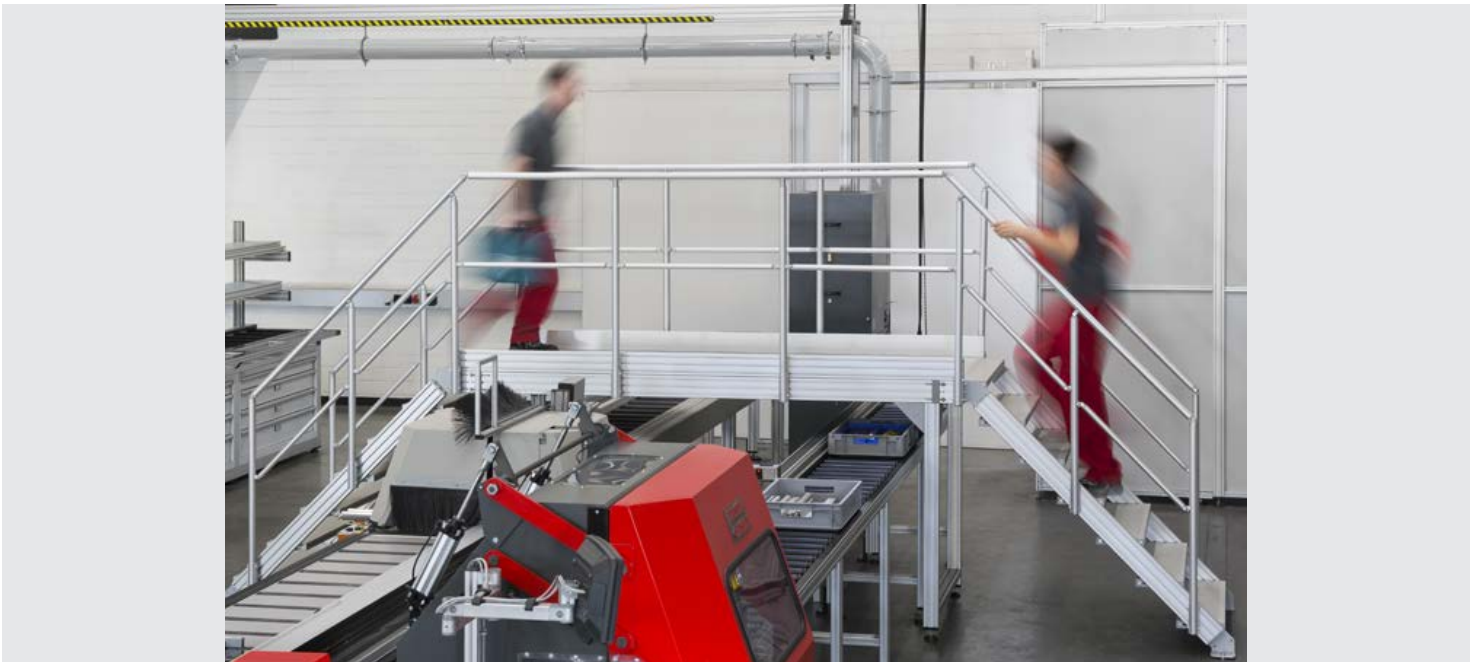
EN ISO 14122 - 3 Permanent means of access to machinery - Part 3: Stairs, stepladders and guard-rails

DIN 51130 Testing of floor Coverings - Determination of the anti-slip property - Workrooms and fields of activities with slip danger, walking method - Ramp test

ASR 17/ 1.2 Traffic routes

BGI 561 Stairways

BGI 181 Floor surfaces in working rooms and areas where there is a slip hazard



Introduction

Primates and swordsmen

It's doubtful whether primates gave much thought to how reliable their first makeshift climbing aids were as they leapt up them to a place of safety away from hungry beasts. If a support gave way, it would be too late to repair it. However, our priorities today when building stairways are also different to those of medieval builders, who favoured spiral staircases that twisted clockwise on the way up. This design automatically gave defenders an advantage, as they had more space to swing their swords down on attackers fighting their way up from below. Although stairways may serve different purposes today, there is one thing about them that has not changed – stairways and platforms are still helpful structures that are used every day, all around the world and with great success. What's more, users don't need to worry about their safety as they use them.

Accidents on stairways

Numerous falls and accidents on stairways have been analysed and one thing is very clear – the main causes of such incidents are poor design and defects caused through use. In Germany, the organisations responsible for statutory accident insurance have collected clear data – in 1980 there were 60,000 reportable accidents on stairways every year. Some 80 percent of stair-

way accidents occurred when the victims were descending the stairs and were usually caused by slipping on the edge of a step. Around a third of all accidents occurred on steps with a going of less than 26 centimetres. By the year 2000 – some twenty years later and following the introduction of building regulations – there were 44,000 accidents per year, down by almost a third.

Standards boost safety

There are countless regulations designed to deliver improved safety for users. The most important can be found in international standard ISO 14122, Safety of machinery – Permanent means of access to machinery. This standard sets out the general requirements for permanent and movable means of access to machinery that cannot otherwise be accessed directly from ground level or from the same level. The guidelines here are based on this standard, which applies to working platforms, walkways, stairways, stepladders and guard-rails that are

- part of a machine
- part of a building that serves primarily as a means of access to a machine
- not permanently attached to the machine but can be put in place and then taken away or moved to the side.

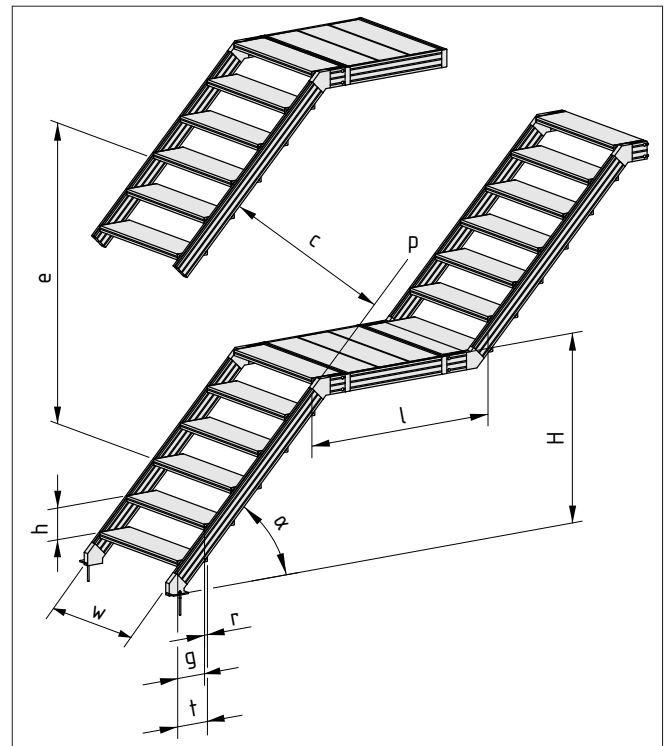
“*Stairways and platforms are still helpful structures that are used every day, all around the world and with great success. What’s more, users don’t need to worry about their safety as they use them.*”

Stairways

Terms and definitions

The flight of a stairway

- H** Climbing height is the vertical distance between the horizontal ground level and the horizontal platform or landing.
- g** Going is the horizontal distance between the nosing* of two consecutive steps.
- e** Headroom is the plumb-vertical distance above the pitch line that should, if possible, be kept clear of all obstacles.
- h** Rise is the height difference between two consecutive steps.
- l** Platform length
- r** Overlap is how far a step extends over the step below. This is based on the difference between the depth of step and the going.
- α** Pitch is the angle between the pitch line and the horizontal ground level.
- w** Width of flight is the distance between two strings.
- p** The pitch line is produced by laying a ruler across all the nosing* in a stairway.
- t** Depth of step is the total depth of a step from the nosing* to the rear top edge of the same step.
- c** Clearance is the distance above the pitch line – as measured at a right angle to the pitch line – that should, if possible, be kept free of all obstacles.



* The nosing is the front upper edge of a step.



The guard-rail

The hand-rail is the uppermost part of a guard-rail that is close to hand. The knee-rail runs in parallel with the hand-rail and helps to prevent users falling through the guard-rail. Vertical columns or balusters can also be used for this purpose, but are uncommon and unnecessary in an industrial environment. Foot-rails stop objects from falling off platforms. They are not required on stairways. The vertical components used to secure a platform or stairway are called stanchions.

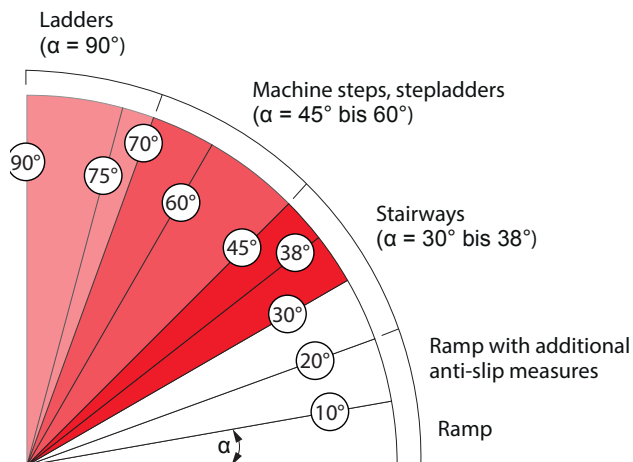
Categorizing by pitch

Stairways have a pitch of up to 45°. They are required as a means of accessing stationary working platforms.

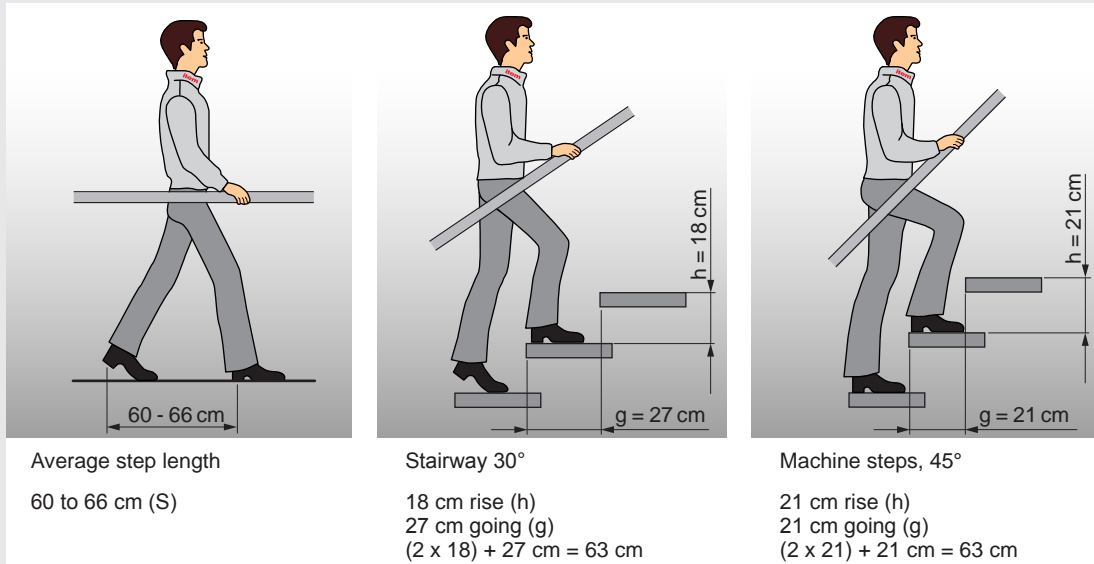
Machine steps and stepladders have a pitch from upwards of 45° to a maximum of 70°. The use of these steps is permitted only when it is not possible to install a stairway due to operational reasons, e.g. because a stairway would narrow a traffic route, adjacent workstations of different heights are connected or a stairway would prevent access to resolve a malfunction.

Ladders have a pitch of 70° to 90° and may be used only when the use of stepladders is not possible for technical and operational reasons.

Defined pitch



- Ladders
(access stairs type 3 as per DIN EN 1034 Part 1)
 - Machine steps, stepladders
(access stairs type 2 as per DIN EN 1034 Part 1)
 - Stairways
(access stairs type 1 as per DIN EN 1034 Part 1)
- α pitch



The basic dimension for all stairways

Applying the step-length rule to steps

The basic dimension in stairway design is step length, i.e. the average distance that someone from central Europe covers in one step when walking in a relaxed manner. This can vary between 60 and 66 cm, so an average value of 63 cm +/- 3 cm is generally used in practice.

When climbing a stairway, an individual moves forward and up, which shortens the step length – by twice the height climbed. The going – i.e. the area of the step where the foot can be set down – also has to be subtracted from the step length. This process of converting pure forward motion into combined forward and upward motion is expressed using the step-length rule:

$$S = 2h + g$$

In other words, rise multiplied by two, plus going, equals the average step length, whereby the average step length of 63 cm is a constant for all stairway calculations.

The ideal going

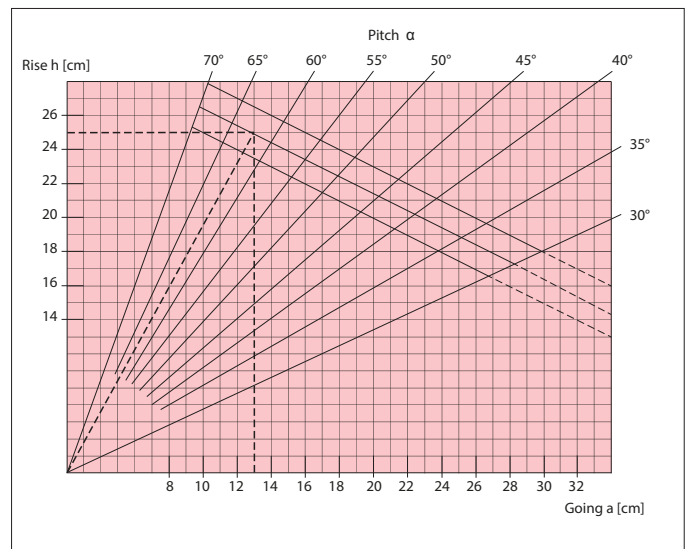
The step-length rule can be used to determine the ideal going for a stairway with a specific rise. The step-length rule is modified for this purpose:

$$g = S - 2h$$

If we select a rise of e.g. 17 cm, the equation is as follows:

$$g = 63 \text{ cm} - 2 \times 17 \text{ cm}$$

The result is the ideal going (g) of 29 cm for stairways with a rise (h) of 17 cm.





The ideal rise

If we approach the design process the other way around, we can also use the step-length rule to calculate the ideal rise for a given going. Again, the step-length rule has to be modified:

$$h = (S - g) / 2$$

If we now insert the going of 29 cm into the equation we get the following:

$$h = (63 \text{ cm} - 29 \text{ cm}) / 2$$

This produces a rise (h) of 17 cm as the ideal rise for stairways with a going (g) of 29 cm.

Stairways in their surroundings

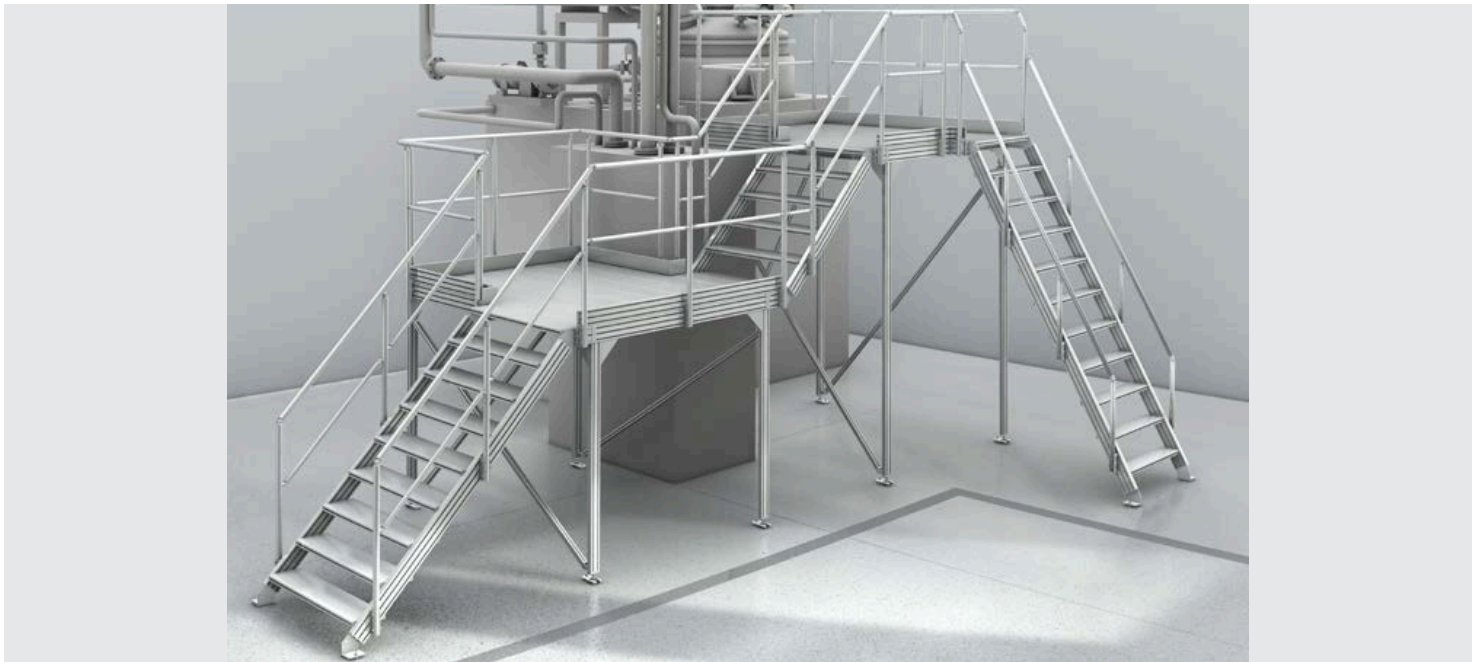
Experience from accidents has shown that the step-length rule is a very practical guide. When working with goings between 26 and 32 cm, it creates rises that are perfect from a safety standpoint. When working with rises between 14 and 17 cm, it

produces extremely safe goings. Stairways with steps that feature a rise of 17 cm, a going of 29 cm and a pitch of around 30° are particularly safe. They are also very easy to climb, since the rise-to-going ratio of 17:29 is also the most economical.

However, it is not always possible to achieve the standard dimensions in industrial environments, where technical circumstances and the available space can play a decisive role. For example, a typical set of machine steps is usually planned with a rise and going of 21 cm each and a pitch of around 45°. Naturally, the higher rise makes these steps steeper and – at 21 cm – the going is also less than ideal. Overall, however, these steps are perfectly suited to their purpose.

Practical experience shows:

In terms of ascending, the step-length rule always produces easy-to-climb stairways. In terms of descending, it can on occasion be desirable to have slightly larger goings.



Safety and comfort

Finding the ideal dimension

The comfort rule and safety rule, which were often cited in the past, are now found only in Austrian standard OENORM B 5371, as a note under Point 4.4 regarding the ideal dimension. They are not mandatory, but they are still helpful.

The comfort rule

In some locations, it is not possible to build stairways with the ideal pitch ratio of 17:29. In such cases, the comfort rule can be used to check the pitch ratio.

Going – rise = 12 cm pitch ratio

This applies to stairways with a pitch of around 30° degrees and is best suited to stairways with rises of between 16 and 18 cm.

Examples of pitch ratios as per this rule are: 15:27, 16:28, 17:29, 18:30, 20:32. The ratios 16:28 and 17:29 are roughly equivalent to a 30° pitch.

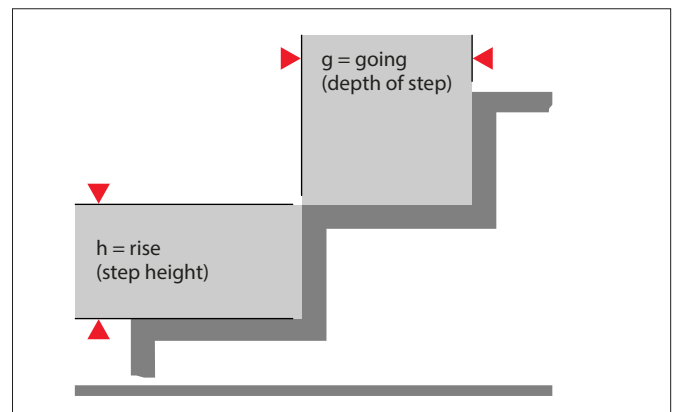
The safety rule

The safety rule produces a pitch ratio between those generated by the step-length rule and the comfort rule.

Going + rise = 46 cm

This rule can be applied to all pitches and still produces good goings even for steep stairways.

Examples of pitch ratios as per this rule are: (shown as rise:going) 15:31, 16:30, 17:29, 18:28, 20:26. The ratio 20:26 is roughly equivalent to a 38° pitch.



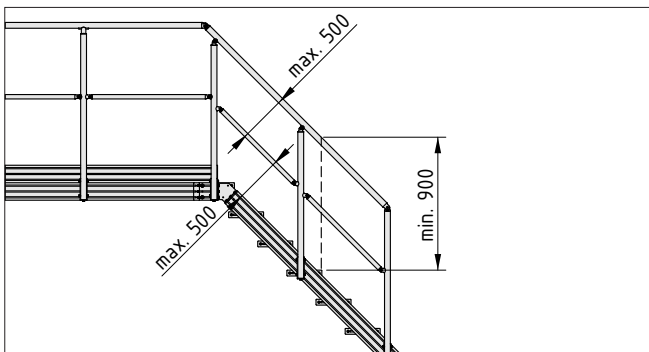


Guard-rails and hand-rails

Even more safety

All open sides on the flights, landings, platforms and openings of stairways must be secured with guard-rails. Specific regulations are set out in EN ISO 14122-3, starting from Point 7.

The height of the guard-rail for a stairway must be between 900 and 1,100 mm – on average 1,000 mm – above the front edge of all steps as measured in a plumb-vertical line.



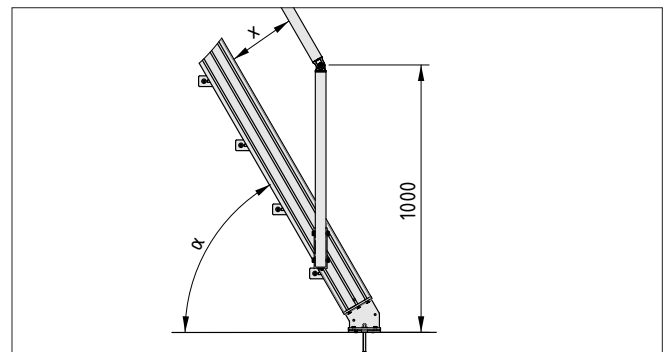
Furthermore, the guard-rail on a stairway must be fitted with at least one knee-rail. The clearance between the hand-rail and knee-rail and between the knee-rail and pitch line must not exceed 500 mm.

Guard-rails for stepladders

In the case of stepladders, the gap between a guard-rail and a step can vary depending on the pitch of the stepladder.

The guard-rail should start at a height of at least 1,000 mm as measured in a plumb-vertical line from the starting floor level.

Pitch α	Spacing x [mm]
60°	250
65°	200
70°	150
75°	100



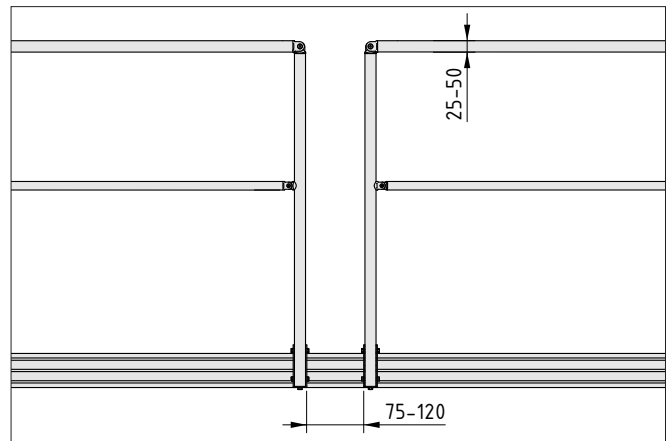
Standard	DIN EN ISO 14122-3
Designation	Permanent means of access to machinery – Part 3: Stairs, stepladders and guard-rails
Contents	<ul style="list-style-type: none"> ▪ Scope ▪ Normative references ▪ Terms and definitions ▪ General and specific requirements ▪ Assembly instructions

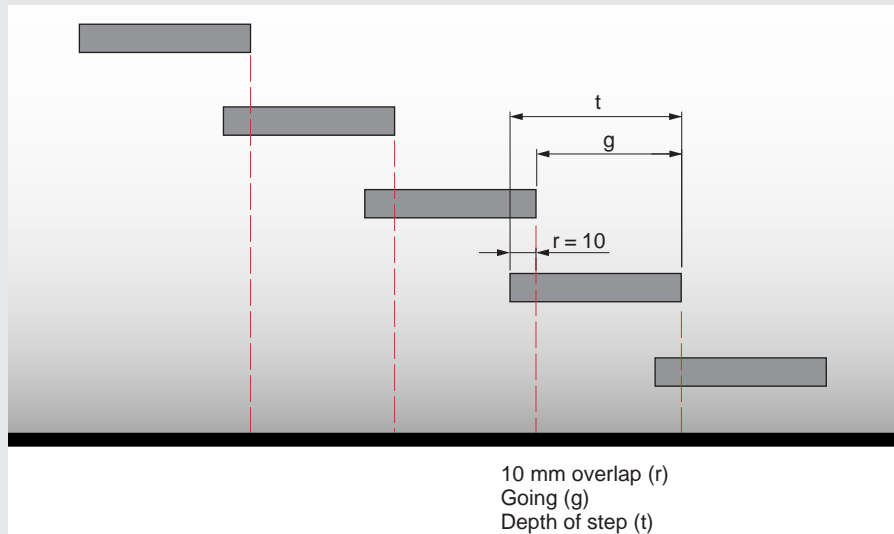


Hand-rail

The purpose of a hand-rail is to offer secure and reliable support. Users should also be able to get a secure grip on the hand-rail. A stairway must have at least one hand-rail, which should be fitted along the right-hand side as viewed when descending. If the stairway is 1,200 mm wide or wider, it should be fitted with two hand-rails. Stepladders, on the other hand, should always be fitted with two hand-rails.

Hand-rails on the open sides of stairways should run the entire length of the flight without interruption. If there are any gaps between the sections of a hand-rail, these must be between 75 mm and 120 mm. A diameter of between 25 mm and 50 mm is recommended for the hand-rail so as to prevent users getting caught on or slipping off the ends.





Safety requirements

Dimensions of stairways

The overlap on a step must be ≥ 10 mm. The rise in a flight of stairs should be consistent. If it is not possible to maintain a consistent rise, it is permissible to reduce the rise from the starting level and starting step by a maximum of 15 percent. It is only permissible to increase the rise in exceptional circumstances and with good reason, e.g. when a moving machine is involved.

It is particularly important that the last step before a platform is the same height as all the others, otherwise that is where the most accidents happen.

The headroom, i.e. the free space above the stairway as measured in a plumb-vertical line, should be at least 2,300 mm throughout. The clearance, i.e. the free space above the stairway as measured at a right angle from the pitch line, must be at least 1,900 mm.

The standard requires that a stairway used in normal circumstances should be at least 600 mm wide, although 800 mm is better. If several people will be using the stairway at the same time, a minimum width of 1,000 mm is stipulated. In special circumstances, which must be evaluated using risk assessments, the minimum permissible width can be reduced to 500 mm.

Individual flights in a stairway must not exceed a height of 3,000 mm. Once this height is reached, a platform must be integrated that is at least 800 mm long and the same width as the stairway.

Dimensions of stepladders

The steps on stepladders must be at least 80 mm deep. The height of a single step – also referred to as the rise – must not exceed 250 mm. The guideline value for overlap is also ≥ 10 mm.

There should be a usable clearance of between 450 and 800 mm – ideally around 600 mm – between the guard-rails which must be fitted on both sides.

The headroom (the free space above the stepladder as measured in a plumb-vertical line) must be at least 2,300 mm throughout while the clearance (the free space above the stepladder as measured at a right angle from the pitch line) must be at least 850 mm.

Curves and turns

Stairways with straight flights are safer than stairways with flights or partial flights that feature curves or turns. In the case of stairways with curves or turns, it is better to ensure these turn in only one direction, i.e. either always to the left or always to the right. However, curved staircases are very unusual in industrial environments.



Anti-slip tread surfaces

The treads on stairways must feature an anti-slip surface in areas where there is an increased risk of slipping. However, it is advisable to use anti-slip materials or surfaces as a general rule.

If the front edges on steps are rounded, they should have as small a radius of curvature as possible. If a stairway is outdoors, additional measures are also required to protect against slip hazards caused by weather conditions. Such measures could include an adequately sized canopy.



Coloured markings and lighting

To ensure users can move up and down stairways safely, it is essential that the steps, and particularly the edges of the steps, are highly visible and easily identifiable. This means that the stairway must be adequately lit. Guideline for workshops ASR 7/3 "Artificial lighting", which is issued by the relevant German institution for statutory accident insurance and prevention, requires that stairways are lit with a nominal lighting level of 100 lux at a height of 0.2 m above the surface of the steps. Safety can be further improved by using risers and treads in different colours or highlighting the edges of steps with coloured markings.

“*The load-bearing structure of an industrial stairway is subjected to widely fluctuating traffic loads.*”

Traffic loads

Stairways under load

The load-bearing structure of an industrial stairway is subjected to widely fluctuating traffic loads. This is taken into account in EN ISO 14122. One person using the stairway without carrying a load corresponds to at least 1.5 kN/m². One person carrying a load or several people using the stairway corresponds to 5 kN/m².



Steps under load

The steps themselves are evaluated separately in terms of traffic loads. Each step with a width of < 1,200 mm must be able to accommodate a minimum load of 1.5 kN on an area of 100x100 mm, as measured at the centre of the nosing. In the case of widths of ≥ 1,200 mm, the step must accommodate the same load of 1.5 kN at several points simultaneously. Measurements are taken at the centre of the nosing and at the most unfavourable points positioned 600 mm apart over the centre.

The following applies to stairways and steps: The load-bearing structure and the steps must not exhibit deflection of more than 1/300 of their span and/or a maximum of 6.0 mm during load tests.

Load-carrying stairway



Ergonomic stairway



Machine steps



Space-saving stairway



The typology of stairways

Less space requires more care

Stepladders are used primarily in industrial buildings as a climbing aid for reaching equipment and machinery in confined spaces. They have recently been used in place of ladders, which were widely used in the past, but are less safe.

Stepladders and auxiliary stairways can have a pitch of 39° to 45°. At 30°, a stairway is very easy to use, even when carrying a load, but it takes up a great deal of space. A pitch of 38° takes up much less space but is still easy and safe to climb and descend. From 45° upwards, stairways become much steeper, but are also very space-saving. The goings are smaller than on standard stairways, which increases the risk of inadvertent slipping. As a result, they should be used only occasionally, ideally only by a small number of personnel with relevant training.

Fundamentally, there is no reason why steep steps and stairways cannot be used, although experts recommend that careful consideration should be given to how they are used. Very shallow

steps with low pitch ratios usually exceed the maximum permissible going of 32 cm that is stipulated for stairways. Nonetheless, the tread surfaces should exhibit a gradient of 2 percent (1:50) to the nosing. As usual, steps and platforms are calculated according to the step-length rule. Even on very shallow steps, all the steps in a flight must have identical dimensions.

Useful guidelines

In basic terms, the following applies: Stairways in special plants that are used frequently by lots of people should have a pitch of between 30° and 38°. Stairways in special plants that are used on an infrequent basis by a small number of suitably trained people, e.g. during inspection or maintenance work, should not be steeper than 45° and should only have an angle of inclination of 60° where this is unavoidable due to space restrictions. These guidelines help to prevent a great many accidents, as statistics from insurance companies show, and are also very practical from an ergonomic perspective.



Platforms, working platforms and walkways

Terms and definitions

Stairway platform or landing: A level area at the start or end of a flight of stairs. Often also part of the floor.

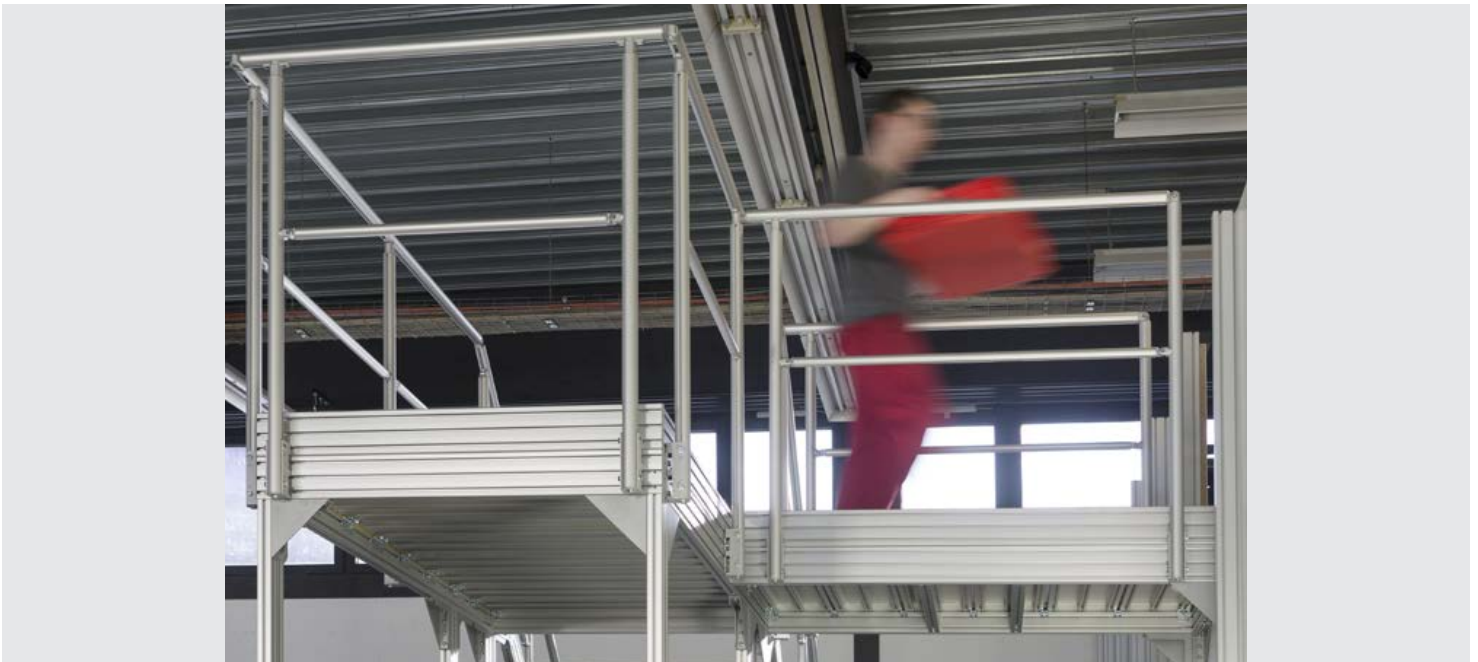
Intermediate platform or landing: A level area between two flights of stairs.

Working platform: Used specifically for phases of work related to a machine.

Flooring: All elements that would normally come into contact with the footwear of users.

Walkway: Level surface used for moving from one point to another





Safety requirements

Platforms, working platforms and walkways also need to be planned, built and arranged in line with safety requirements, just like stairways and stepladders. The basic purpose of a platform or walkway is to give users safe access to their working area and ensure they can carry out all their activities in safety. General requirements include the following points:

Engineering and materials

Parts must be selected and dimensioned to ensure the structures are stable and strong and that all parts can withstand weather conditions. All the components must also be arranged so that there are no areas where water can collect and the combination of materials used must not cause any electrochemical reactions. The dimensions of walkways and working platforms should be based on anthropometric data that has been compiled specifically for that purpose. It is also clear that all structures must be designed so that objects cannot fall off them. To ensure work can always be carried out in safety, it is vital that any machine parts can be removed. It is also important to ensure that personnel can carry out all work activities without having to remove guard-rails, flooring or any other safety barriers.

User safety

All parts that can come into contact with users should be designed so as to prevent injuries. Walkways and platforms must therefore feature permanent anti-slip measures. Natu-

rally, suitable measures must be implemented to stop users falling off at any point. It is essential that users can vacate working platforms and their access points as quickly as possible in an emergency and can be evacuated easily. Hand-rails and other such supports must be installed where they can be used instinctively.

Location

Platforms, walkways and working platforms should be erected as far away as possible from sources of hazardous substances. If moving parts or fluids are in the near vicinity, special safety measures must be implemented as appropriate. A number of specific items, which we will not examine in detail here, require special safety clearances and the closest possible attention, whether building a stairway or platform. As regards the personal location of users, they should be able to work in an ergonomic position, i.e. at a height of between 500 and 1,700 mm.

Dimensions

The minimum headroom above working platforms and walkways should be 2,100 mm. If risk assessments permit, this can be reduced to a minimum of 1,900 mm, e.g. if the structure is used only occasionally or the reduction in headroom is merely a temporary measure. The clear width on a walkway must be at least 600 mm, but ideally 800 mm. If several people are active on it, a width of 1,000 mm must be maintained. If risk assessments permit (see headroom), width can be reduced to a minimum of 500 mm.

“Users must have safe access to their working area and be able to carry out all their activities in safety.”

Flooring

Trip hazards must be prevented. Consequently, the height difference between the surfaces of adjacent floorings must not exceed 4 mm. In the case of flooring that is not solid, openings are considered an appropriate size if a ball 35 mm in diameter cannot fall through them. If workstations are situated below the flooring, such openings must be small enough to prevent a ball that is 20 mm in diameter from falling through. Alternatively, measures should be taken that offer equal protection, such as nets or meshes. Foot-rails should be fitted where the gap between the flooring and the machine, wall or other component next to the stairway exceeds 30 mm.

Foot-rails

Platforms need a foot-rail to stop objects that are lying on the flooring from falling off and to reduce the gap between the knee-rail and the platform. They are necessary when the gap between the platform and the adjacent load-bearing structure exceeds 30 mm. Foot-rails must be at least 100 mm high.





Intermediate platforms

Climbing stairs is tiring. Consequently, large stairways should have an intermediate platform – or landing – after no more than 18 steps. However, intermediate platforms also present a major trip hazard. Studies on accidents show that the biggest risk when climbing stairs occurs when entering a platform and changing gait. As a result, for safety reasons, it is not advisable to include an intermediate platform on a stairway with fewer than 18 steps.

When designing an intermediate platform, the size needs to be adapted to the step-length rule. The platform must be long enough to allow a minimum number of whole steps. How many steps exactly is determined using the:

Platform length formula

Platform length = going + number of steps x 63 cm

Although not mandatory, this formula is very helpful. In any case, safe platforms should be as long as the stairway is wide, but at least 800 mm.

Load assumptions

The traffic loads used as a basis for calculations are a distribution load of 2 kN/m² for the load-bearing structure and a point load of 1.5 kN/m² for the flooring – to be measured at the most adverse point and on an area of 200x200 mm.

When the flooring is exposed to the given load, deflection must not exceed 1/200 of the support width. Furthermore, the height difference between the loaded and unloaded points must not exceed 4 mm. The required load-bearing capacity can be verified on the basis of calculations or measurements.



Hand, knee and foot-rails

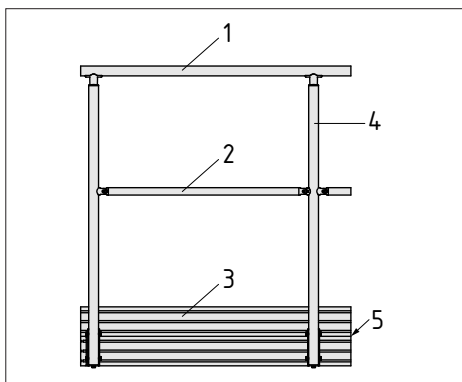
Safety first

Guard-rails must be used above a height of 500 mm from ground level and even at low heights if falling from the stairway or platform could pose a risk of sinking into or smashing through something. Guard-rails are also required when the gap between the platform and the machine or wall exceeds 200 mm. If the machine offers adequate protection, a guard-rail is not necessary. However, a foot-rail must be installed if the gap between the platform and machine is any larger than 30 mm.

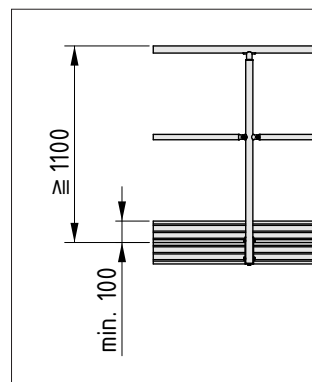
Horizontal guard-rails should be constructed so that users cannot fall through them. The clearance between the hand-rail and knee-rail and between the knee-rail and foot-rail must not exceed 500 mm. Vertical columns must be spaced no further apart than 180 mm, however, these are not commonly found in industrial environments.

Guard-rails must reach to a height of at least 1,100 mm above the step or platform, as measured in a plumb-vertical line. The gap between the central guard-rail stanchions and the load-bearing members should not exceed 1,500 mm. An entryway in the guard-rail must be fitted with a self-closing barrier.

Typical guard-rail design



- 1 Hand-rail
- 2 Knee-rail
- 3 Foot-rail
- 4 Stanchion
- 5 Floor level





Inspection, use and maintenance

As defined by the European Machinery Directive, stairways and platforms are not classed as complete or partly completed machines. No conformity assessment is required, nor is a declaration of incorporation. Instead, they are regarded much more as a permanent part of the overall machine plant and the distributor of the machine plant must therefore conduct a safety evaluation on them in the context of the machine. In other words, the safety of the plant as a whole – including stairways and platforms – is based on the machine itself.

That is why EN ISO 14122 does not stipulate a specific approval process for “permanent means of access to machinery”. Instead, EN ISO 14122 is a Type B standard that sets out clearly and in detail how stairways and platforms should be designed from a safety perspective.

Responsibility

The results of this risk assessment must be incorporated into the design of stairways and platforms. As a result, stairway designers should obtain this information from the operator. As the party commissioning the stairway is responsible for safety and proper use, he too should be well informed.

Checking the requirements for guard-rails

The safety requirements in EN ISO 14122 can be verified by taking measurements and performing calculations. All tests must be carried out in line with the rules for standardised testing as set out in Section 8 of EN ISO 14122-3.

Ensuring safety on a daily basis

In basic terms, the following applies: All stairways must be kept in perfect condition. Regular checks are essential to monitor the condition of the stairway. Stairways are not to be used as long or short-term storage areas. Even an object that is put down on a stairway for a short period of time can cause accidents. Safety demands constant vigilance. Responsibility lies with the contractor.

Regular checks

An individual with the relevant qualifications as stipulated in the applicable national legislation must inspect the stairway daily or at least once a year – depending on its usage and loading – to check its operational safety and look for any damage. The results of these inspections must be entered in a logbook. In the case of steel staircases, a check should also be carried out for corrosion. The aim is to identify dangerous defects in good time, so as to avoid insurance problems. Suitable repairs or modifications should be initiated immediately.



Carrying out repairs

Worn or damaged step edges and treads in particular should be repaired immediately. Damaged edge profiles should also be replaced without delay. Edge profiles should always be fitted flush with the step surface. If repairs to existing stairways result in different rises or goings, appropriate design measures must be taken to compensate for these.

Keeping stairways clean

Wet cleaning and all other upkeep tasks that require a period of drying time should be carried out outside the main times when the stairway is in use. If that is not possible, there should be clear warnings that surfaces are slippery. Step surfaces must retain their anti-slip properties even during cleaning and maintenance work.

Enabling transport

Items should be carried on the stairway in such a way that the individual transporting them always has one hand free to hold the hand-rail. The items being carried must not obstruct the individual's view of the stairway either.

Taking it easy

It is particularly dangerous to rush over stairways. Doing so is a major contributing factor to accidents. Everyone who uses a stairway must be made aware of the need to use it with care. Taking it easy is the key to safety.

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About the publisher

item Industrietechnik GmbH from Solingen, Germany, develops and supplies modular building kit systems that enable customised solutions for all aspects of industrial mechanical and factory equipment engineering. The Building Kit System is based on aluminium profiles, carefully coordinated fasteners and versatile functional elements. Information on the company is available online from its website: www.item24.com.

Detailed information on the TPS Stairway/Platform System can be found at www.item24.de/en/products/building-kit-systems/tps-stairwayplatform-system.