ETTE

Students book

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Introduction

Dear colleague, future colleague, learner,

We hope you and your colleagues go home safe and unharmed tonight. This is why we made this book and the European Safety Passport that accompanies it.

The content reflects the vision that safety is a way of living. Everyone on a stage, a festival or an event, from stagehand up to stage manager, should be able to behave in a safe way, should understand the mechanisms behind working safe and develop a critical safety attitude. In contrast to other safety courses, this book is not focussed on legislation, but on competence, on mastering a safe working practice. It is focused on "being able to" rather than "knowing".

Competence is about permanent training, about constant awareness, about mastering skills. It is not about passing an exam and forgetting the content afterwards. The skills should become part of the way you work, the way you organise yourself. They can change and save your life.

The content of this book is adapted to the specificities of our sector and independent of local practice or legislation. It provides a common ground to ensure that professionals are able to work safe all over Europe, regardless of where they come from or what education level they have.

The book contains ten chapters, reflecting the ten most important skills you need to work safe on stage or at an event. Each chapter contains subchapters that will give you background information for a better understanding of why we should behave in a specific way to work safe. You can read the chapters independent from each other, but is good to read the first two chapters first, to understand the principles and mechanisms behind safe behaviour. You can also read only the first part of each chapter to know how to behave safely and go back to the subchapters later to understand why you need to do so.

Safety is not only about you, it is about all of us, your co-workers, the visiting crews, the artists, the audience. We hope this book will support you in achieving our collective goal to make the stage a safer environment. We also hope that, in whatever function you work, you will become an advocate of safe practice.

The ETTE team.

Copyright note

Disclaimer

The European Commission support for the production of this publication does not constitute an endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

We - the ETTE team - have done our best to create this publication with expertise and care and with the intention to make it user-friendly.

You hold the first version of the publication in your hands. There may still be errors in the text. We are grateful for any suggestions and will correct them for future editions/versions.

The ETTE team cannot be held responsible for incidents or accidents that occur when learning or using the contents of the ETTE manual.

We cannot verify the quality of publications that contain extracts from the ETTE manual and any modifications of the original text, nor are we liable in any way for their accuracy.

The ETTE project

The manual you are reading is the result of the European Theatre Technicians Education project, or ETTE project. During three years (8/2014 - 8/2017), six partners from four countries worked together on this manual through an Erasmus + Strategic Partnership on safety competences. This partnership was supported by the European Union and aimed for innovative practices, cooperation and the exchange of experiences. (Erasmus+ project no.: 2014-1-DE02-KA202-001393 | Key Action 2 – Strategic Partnership)

The partners of the ETTE project were

- Deutsche Theatertechnische Gesellschaft (DTHG) e.V., Bonn, Germany (coordinator)
- Svensk Teaterteknisk Förening, Stockholm, Sweden
- Vereniging voor Podiumtechnologie, Amsterdam, Netherlands
- Stichting Overleg Onderwijs Arbeidsmarkt Theatertechniek, Amsterdam, Netherlands
- Expertise Center Technical Theatre RITCS, Erasmushogeschool Brussel, Brussels, Belgium
- STEPP vzw, Brussel, Belgium

The partnership turned out to be a good mix of training and education providers as well as professionals from the field. This guaranteed the support of the sector and integration in training and education.

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- Stichting Overleg onderwijs Arbeidsmarkt Theatertechniek, Amsterdam, Netherlands: www.vpt.nl/vereniging/stichting-osat.html

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These experts were supported by their associations and organisations, often supporting the expert group in their offices and providing great help. Juliane Schmidt-Sodingen from the DTHG office tied all the strings together, organized the chaos and motivated all the comrades-in-arms.

In addition, numerous colleagues accompanied the project in part with critical remarks, technical assistance, comments and additions.

The development of the practical examination was only possible with the support of trainees and students of MBO college Stage and Event technology Hilversum and WDR Cologne.

Last but not least, the entire project could only be tackled and implemented because the BiBB's national agency in Germany and the European Union's Erasmus + project provided the financial support.

All of these people, even if they cannot be named here, have supported the project in a thankful way and have helped it to be a success.

Preface

„So, take of traps and scenes your fill,
And all you find, be sure to show it!
Use both the great and lesser heavenly light,—
Squander the stars in any number,
Beasts, birds, trees, rocks, and all such lumber,
Fire, water, darkness, Day and Night!
Thus, in our booth's contracted sphere,
The circle of Creation will appear,
And move, as we deliberately impel,
From Heaven, across the World, to Hell!"

Johann Wolfgang von Goethe Vorspiel zu FAUST

When, in the prelude to the FAUST, Goethe put these wishes into the mouth of the theatre director in 1797, he could not in the least imagine how the technical possibilities on the stages of this world develop very soon. Today, the spectrum of stage-based technical possibilities encompasses such a large number of technical means that the safe handling of these makes high demands on all those who work behind the curtain. The task of the stage technician consists of nothing less than realization of always newly invented worlds, which on the stages and then among the astonished spectators, trigger the fascination that the stage art has made for more than 2000 years.

Safety is paramount for the technician. Safety for himself and his colleagues, safety for all artists who work on the stage and safety for the audience - these are the top principles. It is long overdue that for all technical staff, the essential skills and abilities necessary to be able to work on the stage are brought to an internationally accepted level.

Nothing less than that, this project is trying.

Just as art does not stop at any frontiers, the stage technician on all the stages of this world are to speak a common language, that is, to develop a common understanding of all aspects of safe work. In view of the great variety and international differences in working methods, attempts have been made to find the common denominator which ensures a safe working for all. Particular emphasis was placed on not establishing an academic degree, but by providing practical training, particularly through practical help, illustrative examples and well-understood descriptions. It should be the starting point for all those who work together in the boards that mean the world, with creativity, respect, joy and above all with certainty!

Hubert Eckart, CEO, German Theatre Technicians Association

Index

1 Work with respect for own safety

To work with respect for your own safety, you must:

Show awareness of risks related to activities in the performing arts and act accordingly to ensure the own safety.

This means you master following skills:

- Understand the risks in a performance environment and the mechanisms behind them
- Understand your own position in the safety chain and act accordingly
- Work according to safety training and instructions
- Protect oneself against hazards
- Signal risks to a responsible

You master following knowledge:

- Accident theory
- Five steps to reduce risk
- Your rights and obligations

You have following attitudes:

- Safety awareness
- Awareness of your own behaviour

Theatres, festival stages, performing arts and event venues are **high-risk environments**. They are working environments that are extremely complex and constantly changing. Lots of people are working together in the same (limited) space, in limited lighting conditions and with limited communication possibilities. Work on heights and with heavy (hanging) loads is an inherent part of the activities.

Teams from different organizations, with different traditions, work together on and around the stage. They all have tight and absolute deadlines, because at eight the audience comes in. This creates high **time pressure** for every individual involved. Everyone wants as much time as possible on stage to create the expected high quality product. In many cases the teams are multilingual.

The core business of the sector is (per definition) making **new things** or doing the same thing in a complete different venue. This involves a constant use of new materials, new technologies and new methods. The combination of artistic and technical activities creates a double hierarchy with on the one hand the organizational structure and on the other the artistic "line of command".

Fig. 1.1--a Crowded

This makes that everything around you is **changing and moving** constantly. A place that was safe five minutes ago can be dangerous now. In other industries, most of these factors are avoidable, in performing arts and event environments they are part of the essence of the work.

Working safely in this type of complex environment demands a high level of **health and safety awareness** from each of the workers involved. You need to understand how accidents happen and how to minimize risks. Being aware of Health and Safety needs to become a way of living, more than just blindly obeying the rules and regulations. Of course rules and regulations can help and guide us. But applying them blindly is no guarantee for safety. In a complex environment like the performing arts and events sector we expect active involvement, permanent attention and continuous assessment of the situation of the moment. Learning the skills to work safe in such a complex environment is a continuous process. Some tips can get you in the right direction:

Fig. 1.1--b-Beware

- **Be aware of the risks** that your assignment includes and protect yourself. This includes using personal protection equipment (PPE) given, not walking in dangerous zones, etc.
- **Be aware of what is happening around you** and permanently check the safety of yourself and your colleagues.
- **Think ahead** when you do something, check what consequences your actions have.
- **Familiarize yourself** with the working environment and with the organization structure (of that day).
- **Organize yourself** to work safe (order and tidiness, placement of equipment, …).

- **Don't do anything you don't feel capable of** (and let no one push you to do so).
- **Ask questions** when in doubt, talk about safety (and unsafe situations) and propose improvements.
- **Foresee emergencies** (never work alone on heights, check emergency routes and equipment, ...).
- **Stay out of high risk zones**, except if you are authorised and needed there for your work .

When working on stage, you are part of a larger unit that will work, together with you, to keep the safety level as high as possible. Only when all members of the unit **work together** in a consistent way, safety can be improved. It can be compared to a chain that is as strong as the weakest link.

This way of working together is often also organised in a **chain of command**. That is the hierarchy or the order in which acting on emergencies is arranged in an organisation. This hierarchy exists so every employee knows how to act in case of emergency. That is why it is important that you know what your place is in this command chain.

Some people in the organisation will have a better overview of the whole of activities and are able to see risks you don't see. On top of all workers, there will be someone acting as safety officer. The safety officer is the final responsible and also takes care of the formal, administrative, safety requirements. We call this structure the **safety chain or chain of command**. On the one hand they will check, instruct and train you, on the other hand, you will give feedback to them.

H&S is not only about accidents, it also includes **professional illness** and **psycho-social risks**. These are less visual risks, but they can have a major impact in your or others' lives.

Safety is also an investment in **quality and efficiency**. Safe work is better work, if the circumstances are safe, more focus can be put on quality. In the end, safe work is also cheaper work: the cost of accidents, delays, loss of production and loss of reputation can have a major impact on the organization's budget. Order and tidiness provide for a safer situation and also add to efficiency.

Terms and definitions

- working environment
- work on height
- artistic activities
- technical activities
- hierarchy
- rules and regulations
- health and safety awareness
- familiarize
- high risk zone
- emergency
- accident
- professional illness
- psycho-social risks
- safety chain
- chain of command
- safety officer
- professional diseases
- Personal Protection Equipment (PPE)

1.1 Accident theory

At the end of this block, you:

understand the mechanism behind the occurrence of accidents.

We have to realize that **perfect safety does not exist**. For example: To create a perfect burglar safe house, we would eliminate all doors and windows. The house is really safe now, but you can't use it anymore.

Despite how safe we try to work, **accidents happen**. This is a fact. There are two ways to approach this fact. One approach is to consider accidents as bad luck. If we consider accidents as bad luck, karma, fate, shicksal, … it is impossible to change the situation. The reason of the accident is out of our reach so we can't do anything about it. But if we consider the possibility for accidents as a certainty, we can look for the causes and avoid the accident.

Safety will always be a balance between usability and acceptable risk. We put doors in the house, but lock them properly. To make a choice for a balance on a sound basis, we have to understand how accidents happen and what the mechanisms behind it are.

How do accidents occur?

To understand the way accidents happen we need to set some terminology straight and relate the different terms with each other.

Risk

A risk is the **combination** of a dangerous **situation** or **action** with the **probability** that something will go wrong, and the impact it has.

Every unsafe action or unsafe situation will create a certain danger. But this doesn't mean something will go wrong. For example: if you drop a tool when no one is around, no damage is done.

Probability

The probability or chance tells us how big the chance is that things go wrong. One of the factors of this probability is the **exposure** to a risk, i.e. how many people will be exposed for how long. For example, how big is the chance that your tool will hit a person when it falls.

Probability is often misunderstood (or misused to justify unsafe behaviour). We tend to say there is only a **chance** of one percent that something will happen. This expression seems to mean the chance is very small so there is no need for change. To put this in perspective, the same people play on the lottery, where they have a probability of 1 to 45 million to win. A chance of one percent means that there is a statistic possibility that you will have an accident within a period of hundred days or that if you have a hundred colleagues, one of them will have an accident.

Impact

Impact or effect will indicate what the possible gravity of the injuries or the impact on the organization is. For example, when your tool falls, will it cause minor injuries or can it kill someone?

Dia. 1.1.1 Diagram to estimate risk by using probability (chance) and impact (effect).

Incident or near accident

An incident or a near accident is an **undeliberate event with no or very limited damage** or injury that cold could have ended differently. In other words, something dangerous happened, but it ended well. Most people would respond to that saying “we were lucky”. In fact every time you say “we were lucky” is an indicator for a possible accident. This is why it is so important to register near misses. They are very good indicators to steer to prevention.

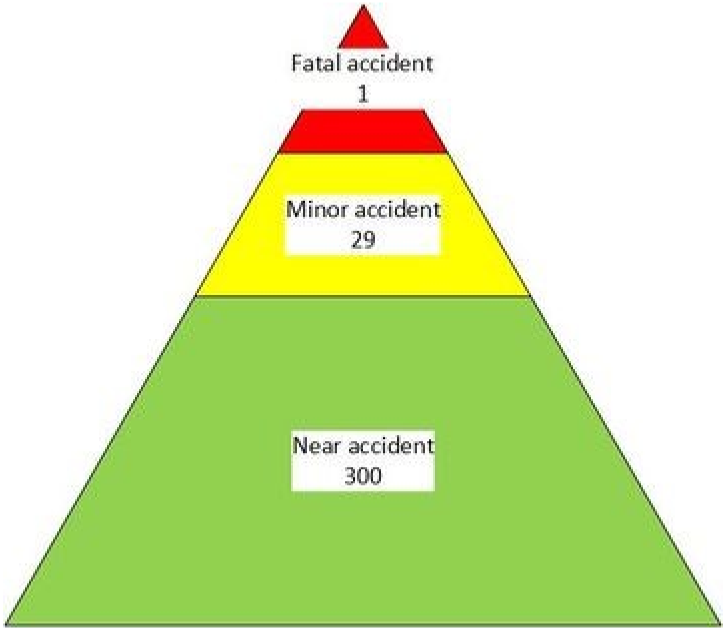
Examples:

- Someone drops a hammer from height without hurting anyone.
- Someone trips over a cable, but doesn't fall and walks on.

Accident

An accident is an **undeliberate event with damage or injury**. In other words, it is an incident that turns out bad. The definition of an accident depends on what we consider serious damage or injury. There is a pyramid shaped **relation between incidents, accidents and fatalities**. For every 300 near accidents, there are 29 minor accidents and 1 major accident. Some safety specialists call this the safety iceberg, because the near accidents often tend to stay under the surface.

Of course these figures are derived from statistical research on large scale. This doesn't mean that in a single organisation the relation between types of accidents can't be different or that **the very first**



Dia. 1.1.2 Diagram safety iceberg

accident couldn't be a fatal one.

Examples:

- Someone drops a hammer from height and hurts someone.
- Someone trips over a cable, falls and hurts him/herself.

Injury or damage

Injuries or damage are the **resulting effect of an accident**. We can classify them in different categories depending on the seriousness and effect.

- **Minor** injuries that are treated on the spot with first aid and no absence of work
- Injuries with **temporary absence**
- Injuries with **irreversible effects** (disabilities, etc.)
- **Death**

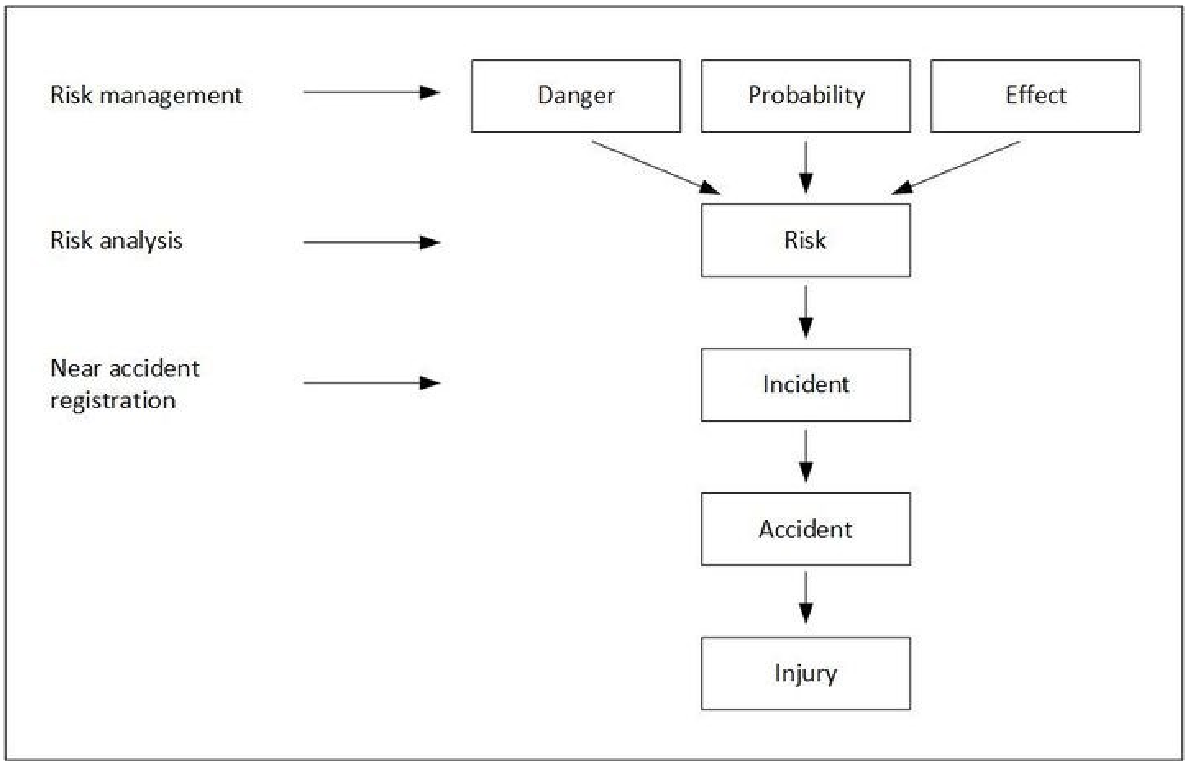
It is very important not **to confuse the cause of the injury with the cause of the accident**. The cause of the injury is what causes the physical damage. For example: a spotlight falling or a sharp knife. The cause of the accident is what action or situation caused the damage to happen. For example: the lack of safety cable or an unadapted way of using the knife.

Examples:

- A severe head wound from a hammer that needs to be stitched.
- Bruises from a minor fall treated with first aid.

Relation

The scheme below shows the relation between the different terms. Danger, probability and effect create a risk. This risk can cause an incident. If this incident goes wrong, it will end up in an accident that can cause injuries. To avoid accidents, we will try to manage the risk factors, analyse the risk and register near accidents.



Dia. 1.1.3 Diagram showing relationship between the accident terminology

Unsafe actions

Statistics show that **80% of accidents are caused by human actions**. So if we want to prevent accidents, the first thing to look at is human behaviour. We need to ask ourselves the question why someone does behave like that? We can split the reasons for unsafe behaviour into three categories.

- Not knowing
- Not being able to
- Not wanting to

Not knowing

Not knowing, as a cause of accidents, is mainly about **lack of information**. If you don't know there is danger or what the consequences of your actions are, it is hard to avoid the risk. If you don't know how to protect yourself or how to react in case of an accident, it will be difficult to minimize the effect of an accident.

Example:

- Hanging speakers without knowing you have to check the WLL of the rigging equipment.

The solution for this problem is simple. **Ask questions** if in doubt, inform yourself about the equipment, the materials and the procedures. And most importantly, admit your ignorance. It seems hard to admit that you do not know something, but you will see it is well appreciated and you will realize nobody has all the answers.

Not being able to

Not being able to, as a cause of accidents, can have multiple reasons. First of all it is possible that you are **physically** just **not able** to do something. Maybe you are not strong or flexible enough to do something. It is also possible you **lack experience** or you don't have the right competence to bring the job to a good end. Or maybe you don't get enough time to do a proper job. These are rather obvious reasons, but sometimes the reasons are less obvious. It is for example possible you are **mentally not able** to do something in a safe way, for example because you lack focus due to your personal situation or because you are scared of what you need to do.

Fig. 1.1--a-Lift-a-speaker

Example:

- You want to move speakers that are too heavy to lift alone.
- You feel ill and need to work on height.

The solution for this lies in the first place in **knowing and admitting your limits**. In this way we acknowledge there is a problem and we can (maybe) do something about it. In any case, don't let anyone force you to do things you don't feel able to.

Not wanting to

Not wanting to, as a cause for accidents, is the most difficult one to deal with because it involves changing people's **attitudes**. Not wanting to use the available safety tools or to work in a safe way can have several reasons. It could be laziness or thinking you know better or a lack of motivation. In most cases this behaviour can be led back to habits that are difficult to change (we have done always this like this, it always went well) or occupational blindness. Occupational blindness means you get accustomed to certain risks in the long run and underestimate them.

Fig. 1.1--b-On-the-head

Example:

- You do not wear your safety shoes, because you always work without them.
- You use tools when working on height without a safety cord, because it costs too much time.
- You use a wrong steel to hang the speaker because you don't want to wait for a proper one.

The solution for these types of behaviour lays mainly in **understanding the reason** behind the need for change and in motivating and monitoring each other.

In the event and theatre sector, with its artistic processes that can be very intensive and artists that can have rather flamboyant characters, there are other factors that can influence safety. That is why some risk management systems go a step further and look at the **background of an individual** worker to understand specific behaviour. They look at character (lazy, insecure, stubborn), education (behaviour learned in other situations, other contexts, where safety isn't an issue or isn't seen as important), organization (bad atmosphere between workers or with management, order and tidiness), and private circumstances. Even if most of these elements can't be influenced, understanding them can help to motivate people for change.

Unsafe situations

Situations that cause a risk to the workers or other people are the second cause of accidents. We can divide them in three types.

- Organization
- Equipment
- Circumstances

Organizational risks are risks that are caused by **the way the work is organized**. These types of risks include scheduling issues between teams or activities (for example if the load out has been organized in a way that conflicts with the "equipment traffic").

Equipment risks have to be seen wider than the strict definition of machines or tools. Other physical elements like staircases or bridges also fall under this definition.

Circumstantial risks involve the environment we work in, not directly related to the action. These are **external elements that influence the activity**. For example limited lighting conditions, weather conditions or extensive noise will influence our work in a negative way.

Coincidence

It would be too simplistic to allot a single cause to an accident. In reality an accident will always be the **result of a combination of circumstances and actions**. Only when this combination occurs, the accident will effectively happen.

Let's look at an example:

A tool falls from a scaffold on someone passing by. If we look in detail we can see a lot of different risks involved in this accident:

- There is a tool on the scaffolding
- There is no protection for falling objects
- Someone is working on the scaffolding
- Someone is passing by

But none of them will cause an accident on their own. The cause of the accident is:

- Someone passes by at the moment that someone, on a scaffolding with no protection, pushes the tool

If we would take away one of the risks, there would be no more cause for the accident.

- If there is no tool, it can't fall
- If there is fall protection, it will not fall
- If no one is working on the scaffolding, the tool would not be pushed
- If no one can pass by, we only would have an incident.

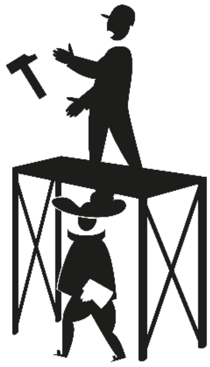


Fig. 1.1--C-Scaffold

But **not all risks can be eliminated**, otherwise the work won't get done. The alternative is to **avoid coincidence**. We can make sure the risks can't occur at the same time. In other words:

- If a person can't pass by when we are working on the scaffolding, there can't be an accident.

Avoiding coincidence is a method used a lot in situations where we can't avoid risks.

Professional illnesses

Professional illnesses are not the result of an accident. The injuries or damage to the body are not a result of a sudden event but of **long time exposure** to unsafe or unhealthy circumstances. Typical examples are hearing damage through long time exposure to loud noise, back injuries from repetitive lifting or eye problems from intensive, long term screen work. The fact that the injuries are **not directly related to a specific event** makes it difficult to prove there is a relation with the work activity and to prevent this type of injuries.

More ergonomic working methods, the right protection equipment and variation of work are the most accurate remedy for professional illnesses.

Psychosocial risks

Psychosocial risks are **risks for mental and physical health** that find their origin in the content or the context of the work. Content includes the job content, the workload, schedules and the means to work with (workplace, equipment, etc.). The context of the work includes the amount of control you have, organizational culture, relationship with colleagues, career possibilities and work-home balance. These risks can turn into extreme stress, depressions, and burnout or bore out, but also into physical complaints like musculoskeletal disorders or cardiovascular diseases.

Most organizations have policies to deal with sexual harassment, improper behaviour, bullying, etc. **Signalling problems in time** can help to minimize the effects of psychosocial risks.

What you need to remember

- Safety will always be the result of a balance between usability and acceptable risk.
- A risk is the combination of a dangerous situation or action with the probability that something will go wrong, and the impact it has.
- There is a relation between risks, incidents, accidents and injuries
- The causes of unsafe actions (not knowing, not being able to, not wanting)
- The types of unsafe situations (Organization, Equipment, Circumstances)
- The importance of coincidence in avoiding accidents

Terms and definitions

- Accident
- Risk
- Probability
- Impact
- Danger
- Unsafe action
- Unsafe situation
- Hazard
- Probability
- Impact
- Incident
- Near accident
- Damage
- Injury
- Fatalities
- Occupational blindness
- Organizational risks
- Equipment risks
- Circumstantial risks
- Coincidence
- Professional illness
- Psychosocial risk

Nice to know :

More evolved systems

Very often "exposure" and "probability" are treated as completely different aspects of a risk. In this perspective, a risk is a combination of 1) probability, 2) exposure, and 3) impact. Most of the time, you cannot influence one or even two of these elements, but sometimes you can reduce the risk to an acceptable level by influencing the remaining element(s).

The formula R(isk) = P(robability) x E(xposure) x I(mpact) is useful, not so much because of the exact outcome of the calculation, but to show the principle that often you can reduce a risk by reducing one or two of its elements.

OiRA

The European Agency for Safety and Health at Work (EU-OSHA) developed a web platform that enables the creation of sectoral risk assessment tools in any language in an easy and standardised way. It is called OiRA (Online interactive Risk Assessment). For the live performance sector, two tools have been developed, a first one for productions and a second one for venues.

Among other things, the tools cover the technical elements in relation to set, rigging and stage; the special elements, stunts and artistic performance activities on the stage; the chemical and hazardous substances used in special effects; frequent high noise levels; and the presence of an audience. The Live Performance Productions Tool also includes the cooperation between the production and the different venues hosting productions when going on tour.

https://oiraproject.eu/en

Evaluation of risks:

There are **several models to identify the potential danger**. Some tell the risks in text, other use numbers to give a value to the risk. All these are based on the Fine and Kinney method of risk assessment.

IMPACT	LIKELIHOOD				
	Rare	Unlikely	Possible	Likely	Almost Certain
Catastrophic	Medium	Medium	High	Critical	Critical
Major	Low	Medium	Medium	High	Critical
Moderate	Low	Medium	Medium	Medium	High
Minor	Very Low	Low	Medium	Medium	Medium
Insignificant	Very Low	Very Low	Low	Low	Medium

Dia. 1.1.5 Diagram to estimate risk described by words.

Impact						
Extreme/ Catastrophic	5	10	15	20	25	30
Major	4	8	12	16	20	24
Moderate	3	6	9	12	15	18
Minor	2	4	6	8	10	12
Insignificant	1	2	3	4	5	6
		1 Remote	2 Unlikely	3 Possible	4 Probable	5 Highly Probable

Likelihood

Dia. 1.1.4 Numeric diagram to estimate risk

In the scheme above, risk is **expressed by the numbers** in a linear way, but often, an exponential series of numbers is used, with an outcome between less than 20 (negligible) and more than 400 (very high risk) to bring the risks more in line with the reality.

Once a risk is evaluated, measures will be taken to reduce the risk, after this, the risk is **evaluated again** until the risk is at an acceptable level.

Rehearsal questions

01.01.01 True or false:

- Risk = unsafe action x probability x impact

01.01.02 True or false:

- An incident and an accident is the same thing.

01.01.03 True or false:

- The cause of an injury is the same as the cause of an accident.

01.01.04 True or false:

- The outcome of an accident is always damage or injury.

01.01.05 True or false:

- There are more accidents than incidents.

01.01.06 True or false:

- The result of an accident can never be a minor injury.

01.01.07 True or false:

- Unsafe actions and unsafe situations are the same.

01.01.08 True or false:

- Unsafe actions and unsafe situations can cause the same risk.

01.01.09: True or false

- It is possible to make any situation 100% safe with the same usability.

01.01.10: Someone trips over a piece of wood left laying around without hurting himself, this is an example of a

a) Risk
b) Near accident
c) Accident
d) Disaster

01.01.11: Someone cuts his hand with a knife, with a wound as a result. The cause of this accident is:

a) Not using the proper personal protection
b) The use of the knife
c) The sharpness of the knife

01.01.12: True or False

- More accidents happen through unsafe actions than through unsafe situations.

01.01.13: Not wearing a hard hat is an example of

a) Not knowing
b) Not wanting to
c) Not being able to

01.01.14: A tool falls from a lighting bridge during focus on an actors head. The reason of this accident is:

a) The actor being on stage
b) The technician focussing
c) The absence of a side board
d) The combination of the above

01.01.15: True or false

- Professional illness is the result of a work related accident with permanent consequences

1.2 Five steps to reduce risk

Before you start, you should read the chapter 01.01 Accident theory .

At the end of this block, you:

- can apply the five steps to reduce risks.
  - Eliminating the risk
  - Collective protection
  - Individual protection
  - Training
  - Information, notification and warning
- know the basics of risk assessment.

Based on the accident theory, we identified risks. The next step in the process of risk management is to take measures to make the situation safer. The way to do this depends on the total situation. Where possible, we will **tackle the causes** of a possible accident by avoiding risks or **avoiding a coincidence** of risk factors. Where this is not possible, we will try to minimize the effect.

The principle is that we evaluate the risk, take the best measure possible and **evaluate the resulting risk until it is acceptable**. It is important to include the whole of the situation in the evaluation, because it is possible that you create another risk by reducing one risk factor.

Pic. 1.2-1 slope stage

There are five types of measures we can take. Some have a higher guarantee for a safe situation than others, but **not all measures are applicable to every situation**. In some cases, reducing the risk would also end the functionality of the action we try to protect. To show this with an example: The best way to protect your house against burglars is to eliminate all doors and windows. It is perfectly safe now, but it is no longer useful. Choosing the right measure is always a balance between safety and usability. The five types of actions (from best to least good) are:

1. Eliminating the risk
2. Collective protection
3. Individual protection
4. Training
5. Information, notification and warning

Eliminating risk

The best action possible is to eliminate the risk. If we **take away the possible cause of an accident**, there is no longer a problem. This sounds very evident, but in reality this type of solution is overlooked a lot of times.

Some examples:

- We have an opening in the stage floor (trap door, orchestra pit, elevator, …) and there is a risk people fall in the opening. Closing the opening eliminates the risk completely.
- We want to hang a spotlight on a bar. Not hanging the spotlight is no option, we do need light on stage, by eliminating the risk we would also eliminate the essence of our action.
- Using a trapeze in a circus performance is essential, without trapeze, there is no show.
- The use of a sound system on stage is essential and unavoidable.
- The use of tools and equipment on stage is unavoidable, but we can eliminate them from walking zones and organize them in flight cases or dedicated storage spaces. The risk of tripping over equipment and tools is eliminated in the walking zones and moved to other areas.

Collective protection

When we can't eliminate the risk, we will try to **protect everyone** against it. This can be done by collective means, measures that protect everyone. When developing collective solutions, we have to take into account the differences between users. Children, elderly or disabled people may need adaptations in collective protection.

Some examples:

- We have an opening in a stage floor (trap door, orchestra pit, elevator, …) that is needed at the moment. Building a fence around the opening protects everyone. No one can enter, so no one can fall. In this case it is important to identify who is everyone. If children are involved, there will be a need to reduce the openings in the fence.
- Hanging a spotlight on a bar will create a risk of falling, especially because the spotlight is hanging above the heads of the people. The risk would be a breaking bolt or brace. A safety cable will stop spotlight from falling and secures everyone.

- One of the risks of using a trapeze on stage is an artist falling on a passerby. Fencing off the area ensures no one can stand under the trapeze. Securing the access to the trapeze will ensure no one can climb up.
- Sound systems can be electronically protected against unacceptable levels of sound.
- Extraction systems protect all by cleaning the air.

Individual protection

In most cases, collective protection makes it impossible to manipulate equipment. We also need to **protect the individual** working with the equipment. This doesn't mean we don't need collective protection as well, to protect the others. So here we will have a double protection in a lot of cases, a collective one for all standing outside the action and an individual one for the workers that need to manipulate. The disadvantage of individual protection is that it relies on the individual who is responsible for using it.

There are two types of personal protection. On the one hand we have **protection against accidents happening**, on the other hand we have protection that **minimizes the effect** of an accident.

With most individual protection, there will **still remain a certain risk**, you might still get hurt, but the damage will be limited to an acceptable level.

Some examples:

- A harness with a lifeline will stop you from coming to close to the opening on stage.
- Safety shoes will minimize the effect of a spotlight falling on your toes.
- A hard hat will protect you against falling tools when someone is working above your head. It will still hurt, but the damage will be acceptable.
- A harness with lifeline will not protect the trapeze artist from falling, but it will protect him from hitting the floor, even if it will be an unpleasant experience.
- Hearing protection will protect you against high sound levels on stage.

Training

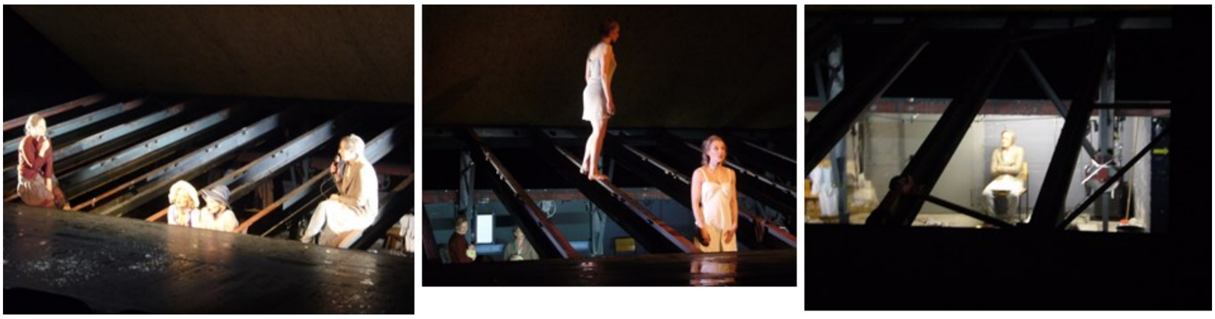
In some situations, especially when working in an artistic environment, it is difficult to protect people. Some protection measures will conflict with the artistic vision, ruin the meaning of the performance, or influence the desired image. In some countries, taking (calculated) risks for performance would even be considered freedom of speech.

We can **reduce these risks by training** people. They need a deep understanding of the risk factors, rehearse how to behave and how to respond in case something happens.

Some examples:

- We have an opening on stage for a disappearing act. We need to train the actors and other people that are on stage how to behave when the trap door is open.
- Flying on a trapeze is a high risk activity, but the trapeze artists will be trained for years to deal with this risk. Crew members will be trained to act in case of emergency. If the trapeze artist falls and hangs on a lifeline, someone needs to be trained to bring him or her down.
- A spotlight could blind you, training on how to manipulate a spotlight will reduce risks.
- A sound person needs to be trained to use sound in a safe way.
- An actor needs to be trained to use a gun on stage, to avoid hearing damage or burn wounds.

Next to situations where training is the only option, being able to apply **collective and individual protection will require training too**. These measures are only effective if applied in the proper way.



Pic. 1.2-2The actors have to be trained step by step during the rehearsals

Information, notification and warning

The last step is to warn and inform all people that get in contact with the risks. **Warning and notifying doesn't reduce risks** or effects of an accident, but it makes people aware of them.

Warning includes all types of **signage** (warning signs on doors etc.) that draws people's attention to the risks in a specific area. Signs will also indicate the personal protection needed in these areas and safety equipment that is available. Concrete risks will be made **more visible** by marking them or lighting them up. Informing people will help them to deal with specific situations. Work post sheets will give **instructions** for safe use of equipment, and safety sheets will give detailed information on the way products have to be handled.

Procedures, explaining agreed actions and responsibilities (the rules of the house), **will inform people how to behave** in specific situations. This type of information has to be repeated on a regular basis. In some organizations these instructions are implemented in daily briefings.

Some examples:

- An opening on stage will be made visible with LED strips around it.
- Signage at the door of the stage will warn about hanging loads, openings on stage etc. There will also be a sign to wear safety equipment. Emergency exits and equipment are marked.
- Before the show starts, the crew will be briefed on the procedures and emergency procedures for the trapeze act.

- Spotlights with a high light output will have a danger sign warning against looking directly into the lens.
- A notice at the doors warns audience members that strobe effects are used.
- Black and yellow tape marks safe walking paths. Stairs or obstacles are marked with phosphorescent tape that lights up in the dark.
- A sound signal will warn you for a truck backing up to the loading dock.
- A light signal will warn for moving elevators in the under stage.

Combination of measures

In most cases, we will need to take **several measures to reduce the risk** to an acceptable level. We start to reduce risks by following the five steps from above. After each step we evaluate the risk again and take extra measures until the risk is acceptable.

Fig. 1.2-a-Harnass

Some examples:

- An opening in a stage will always be closed, except when needed. At that moment we will put fences to protect everyone. People that have to work inside the fence are protected with a lifeline and be trained to do so. As an extra, people will be warned and the opening will be signalled.
- To protect you from falling you need to wear a harness. To use this properly you need to be trained. To ensure you wear it in the right situations, you need to be informed.

It is important to **take in account the whole of the situation**, with all risks involved. It is possible that you create another risk by reducing one risk factor. The evaluation of the situation will identify the new risk.

Example:

- We replace the use of fire on stage with a projection effect on water. The fire risk is eliminated, but new risks occur by using the water.
- Using a hard hat reduces the risk for head injuries, but limits the view above you.

In the totality of an activity **multiple risks** can occur. It is important to tackle them one by one to make the entire activity safe.

Example:

- When connecting two high set pieces, one worker will connect the sets together on the floor, while a second one will keep the sets together. Of course the worker below will wear a hard hat. Once the connection below is finished, the ground person will clear the floor and ensure no one can stand under the worker above.

Unexpected risks

Of course some risks cannot be foreseen. These risks will not be formalised in the risk assessment. For these situations a **last minute risk assessment** is a solution. This is an "on the spot" assessment carried out by the workers themselves. They make a quick analysis of the situation and reduce the risk based on the principles of the five steps.

Look out for false safety

The worst thing that you can do is **make people think a situation is safe**, while in fact it is not. This creates even more dangerous situations, because we lose the awareness of the risk.

Some examples:

- Putting a thin triplex plate on top of an opening on stage, it looks safe now, but if you would walk over it, you would fall through it.
- Putting red and white barrier tape around an opening on stage. The tape will not support a person falling or leaning, but it gives a (false) safe feeling.
- Using a hard hat gives the feeling that you can't be hurt. This could cause people to walk under hanging loads deliberately (and unnecessarily).

Fig. 1.2--b-Heavy-weight

Risk assessment

Risk assessment is the **process** of detecting risks and proposing measures to improve health and safety to an acceptable level. In fact assessing risks is a very natural thing to do. When you want to cross the street, you will assess the risks and based on this assessment you will cross or you will wait until the situation is safer. Maybe you will even decide to take a small detour to cross at a safer place.

The idea behind risk assessment in a working environment is not different. The only thing that is different is the fact that it is **formalized**. This is needed because it involves a group of people in a complex situation. It is part of the whole of risk management actions of an organization. It needs to be documented to be useful for the whole organization.

Risk assessment is a **tool**, a methodology that helps us to detect risks, propose measures and document this process. But it is not a goal or an objective on its own! The objective is to create a safer working environment, not to fill the paperwork. If the paperwork becomes the priority there is a reasonable risk for false safety.

Risk assessments can be made **on different levels** and for different situations. A large organizational can contain different sub-assessments with assessments of buildings, work posts and processes. Some of these assessments will be rather static, the building will be there for a long time and this situation doesn't change that much. Other assessments will be more variable, as productions change permanently.

All the risk assessments have to be seen **as a whole**. It is perfectly possible to bring a safe production on a safe stage and create new risks by doing so. If situations change, the risk analysis has to be updated. So risk assessment is a continuous process.

If risks that are not foreseen appear during the work process, it may be necessary to do a **last minute risk assessment**. This is an “on the spot” assessment carried out by the workers themselves.

Formal risk assessment is a complex job, which needs specific skills and insights. This goes beyond the scope of a basic safety training. You don’t need to go in depth here, but you need to understand the basics to understand why this is important and what your contribution in the process is.

There is a variety in risk assessment **methodologies**, each with their advantages and disadvantages. Some are numeric, assigning figures to the risk, the probability, the frequency and eventually the level of training. Others are more text based, connecting expressions to certain parameters.

Fig. 1.2-c-Risk-assessment

Risk assessment systems help to **prioritize** actions. It is not always possible (or necessary) to take direct action for specific risks. This depends on the gravity of the risk, the exposure rate and the reality. A risk management system will also take in account the reality of the organization. More specific the cost of a measure, the planning, loss of production time, deadlines, … It is also possible that the risk will disappear by itself in the future (planned rebuilding, moving, end of production, etc.). Depending on all these factors, taking action can be needed immediately or can be postponed to a certain deadline.

Your job in the process of risk assessment is to give input, to signal risks to the safety responsible, to make a last minute risk analysis of situations that were not predicted and of course to follow the recommendations resulting from the risk analysis.

What you need to remember

- The five steps to reduce risks, how they are combined and what they mean
  - Eliminating the risk
  - Collective protection
  - Individual protection
  - Training
  - Information, notification and warning
- Unexpected risks, last minute risk assessment and false safety
- The principle of risk assessment

Terms and definitions

- Last minute risk assessment
- Risk assessment
- Risk evaluation
- Unexpected risks
- Measures
- Eliminate the risk
- Collective protection
- Individual protection
- Acceptable risk level
- False safety
- Protecting measures
- Harness
- Eliminating risks
- Risk management

Rehearsal questions

01.02.01: Put in the right order, from best to less effective

a) Individual protection
b) Collective protection
c) Training
d) Eliminating the risk
e) Information, notification and warning

01.02.02: Wearing a hard hat is an example of

a) Eliminating the risk
b) Collective protection
c) Individual protection
d) Training
e) Information, notification and warning

01.02.03: Locking the door of a electrical cabinet is an example of

a) Eliminating the risk
b) Collective protection
c) Individual protection
d) Training
e) Information, notification and warning

01.02.04: A safety briefing is an example of

a) Eliminating the risk
b) Collective protection
c) Individual protection
d) Training
e) Information, notification and warning

01.02.05: An evacuation drill is an example of

a) Eliminating the risk
b) Collective protection
c) Individual protection
d) Training
e) Information, notification and warning

01.02.06: True/False:

- When we take a safety measure, the risk no longer exists.

01.02.07: Multiple answers

If we discover a risk during work,

a) we carry on, because it is not in the risk assessment.
b) we make a last minute risk assessment.
c) we warn the responsible.

01.02.08: True/False:

- You always have to apply the 5 steps to minimize the risk.

01.02.09: True/False:

- Collective protection is often used in combination with individual protection.

01.02.10: True/False:

- All risks are formalised in a risk assessment.

01.02.11: True/False:

- In the process of the risk assessment you as a technician have to give input and signal risks.

01.02.12: True/False:

- Your job is to make a last minute risk assessment in every risk situation.

1.3 Your rights and obligations

At the end of this block, you:

know the basic rights and obligations of employer and employee.

In order to ensure that **every worker in Europe is treated the same way** concerning health and safety, the EU has defined some basic rights and obligations for both employer and employee. These rules are translated in national or regional legislation in each member country. Of course the countries are free to use higher standards, but the ones below are the minimum agreed for all.

Pic. 1.3-1 European flag

The worker shall:

- **make correct use** of machinery, apparatus, tools, dangerous substances, transport equipment, other means of production and personal protective equipment
- immediately **inform** the employer of any work situation presenting a serious and immediate danger and of any shortcomings in the protection arrangements
- **cooperate with the employer** in fulfilling any requirements imposed for the protection of health and safety and in enabling him to ensure that the working environment and working conditions are safe and pose no risks.
- **Health surveillance** should be provided for workers according to national systems. Particularly sensitive risk groups must be protected against the dangers which specifically affect them.

The employer shall:

- **evaluate all the risks** to the safety and health of workers, inter alia in the choice of work equipment, the chemical substances or preparations used, and the fitting-out of work places
- **implement measures** which assure an improvement in the level of protection afforded to workers and are integrated into all the activities of the undertaking and/or establishment at all hierarchical levels
- **take into consideration the worker's capabilities** as regards health and safety when he entrusts tasks to workers;
- **consult workers** on introduction of new technologies;

- **designate worker(s)** to carry out activities related to the protection and prevention of occupational risks.
- **take the necessary measures for first aid, fire-fighting, evacuation** of workers and action required in the event of serious and imminent danger
- **keep a list of occupational accidents** and draw up, for the responsible authorities reports on occupational accidents suffered by his workers
- **inform and consult workers** and allow them to take part in discussions on all questions relating to safety and health at work;
- ensure that each worker receives **adequate safety and health training**

source: https://osha.europa.eu/en/legislation/directives/the-osh-framework-directive/1

What you need to remember

- Your basic rights and obligations are guaranteed all over the EU in the same way.
- Your obligation is to work in a correct way, to inform and work together with the employer to improve health and safety.
- Your employer needs to evaluate the risks, take measures, inform and consult with the workers, and provide protection equipment and training.

Terms and definitions

- Basic rights and obligations
- National or regional legislation

Nice to know :

European directive, responsibility of workers

The European directive protects the workers, but this does not mean the **workers have** no **responsibility**. Especially when an action is deliberate or the worker does not want or refuses to do something, this can have legal consequences.

A worker who refuses to wear safety shoes can be held accountable in case of an accident. The same counts for someone climbing on the outside of scaffolding instead of following the directions to climb inside.

Another example is the deliberate removal of safety measures on machines and equipment. In these cases you can be held responsible for the consequences. This can mean the insurance will recover the costs from you or even that you are accused of a felony in case someone else is hurt.

Rehearsal questions

01.03.01: Countries or regions can:

a) Not change anything to European basic health and safety rules and regulations.
b) Set higher standards than the European ones.
c) Set lower standards than the European ones.

01.03.02: True or false

- Sensitive risk groups have the right to extra protection against hazards that affect them.

01.03.03: True or false

- The employee has the duty to evaluate all the risks to the safety and health in the company.

01.03.04: True or false

- The employee has the duty to inform the employer about immediate danger.

01.03.05: True or false

- The employer must consult the workers when introducing new technology.

01.03.06: The employee must (multiple answers)

a) Follow training provided.
b) Be able to firefight.
c) Use personal protection equipment correctly.
d) Keep a list of accidents.

01.03.07: Health and safety is

a) The responsibility of the employer.
b) The responsibility of the worker.
c) A shared responsibility.

01.03.08: True/False

- The basic rights and obligations of a worker are being defined by your country.

2 Contribute to a safe and sustainable working environment

To Contribute to a safe and sustainable working environment, you must:

Show awareness of risks related to your and your colleagues’ activities on stage and in the audience area in the performing arts and act accordingly to ensure the own safety.

This means you master following skills:

- Works with attention for the safety of colleagues, artists, public and other stakeholders.
- Detects, prevents and protects against risks and injury (such as electric shock, hearing damage, hazardous substances, tripping, fire, …)
- Pays attention to minimum lighting conditions and sound levels on stage to ensure orientation and communication during setup, focus, sound check, rehearsal and performance.
- Works with attention for the sustainable use of materials and energy.
- Proposes improvement and prevention measures.
- Informs him/herself about the regulations and practices in unfamiliar workplaces.
- Works according to the rules and regulations of the workplace.
- Mounts and uses collective protection equipment where needed.
- Acts according to the agreed procedure in case of an emergency.
- Complies with legal working time regulations.

You master following knowledge:

- 02.01 Risks on stage
- 02.02 Safety in the audience area
- 02.03 Sustainability
- 02.04 Safety Legislation
- 02.05 Danger signs
- 02.06 Prohibition signs

You have following attitudes:

- Safety awareness
- Awareness of others’ behaviour

You are not alone when you are working on stage. You will work together with colleagues from your own team, the house you are visiting, or the company that is visiting. They can be professionals or amateurs. In some cases this team will also include external contractors, freelancers, volunteers etc.

More and more performances happen **outside the traditional theatre stages**. Sometimes you even work on a location that is not designed for theatre or events. The workers in such locations are unfamiliar with performance traditions and probably have no training in our field at all.

When we are working, we work in the same space as the **performing artists**, the administrative and artistic **staff** and the **audience**. They are not around the entire time, but can show up at the most unexpected moments. These people must be treated as "untrained persons, not familiar with the situation". They are at risk and form a risk at the same time.

Working with so many different types of people in the same space requires attention. We have to ensure:

- Not to bring them in danger
- That they can move safely
- That they can work safely
- That they can't perform dangerous actions

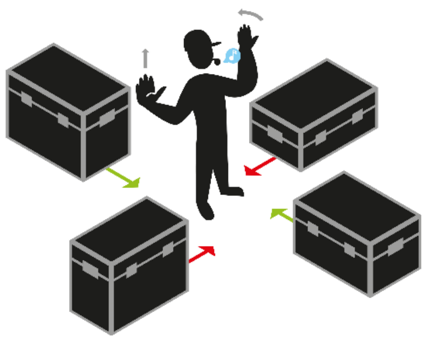


Fig. 2.0.a-Traffic

- A safe exit in case of emergency

How to behave

The most important part of taking care of a safe and sustainable environment is a constant awareness of your environment. Some general guidelines:

- **Look around** and observe the situation permanently.
- Always **organise** your work to avoid hazards for others.
- Be **conscious** about others' activities.
- **Warn** people when unsafe situations occur.
- **Talk** to people about their safety behaviour.
- **Check** lighting conditions.
- **Secure** high-risk zones.
- Organise the **focusing** of spotlights as to not hinder others.
- Organise **sound** checks as to not hinder others.
- Organise the **build of sets** as to not hinder others.
- Speak out loud when performing **riskful actions** (like lowering fly bars)
- Maintain zero tolerance for **alcohol, drugs and medication** that may influence your actions.
- **Prepare for accidents** to happen.

If you see dangerous situations, you have a warning duty. Warn the safety responsible or stop if you think there is immediate danger.

When working, we also have a responsibility towards society. Working sustainably within the boundaries of our work will minimise the impact of the production process on the environment and the people.

Some practical suggestions can show what we can do:

- **Reduce** the waste of energy by using working lights instead of performance lights.
- **Switch off** the lights when nobody is present.
- **Minimise the use of consumables** or try to replace them with reusable equivalents.
- Where you have the choice, make sure that you use **environmentally friendly alternatives**.
- **Dispose** of unavoidable waste separately and make sure you use **recycling** facilities where provided.
- Where applicable (i.e. travelling to work or to different locations at work), use environmentally friendly modes of **transport** such as a bicycle or public transportation.
- Make sure that **accessibility** for colleagues, artists or audience members with disabilities is never compromised.

Terms and definitions

- Warning duty
- High-risk zone
- Working lights
- Performance lights
- Safety awareness
- Untrained person

Nice to know

Organisational procedures

Of course taking care of risks is an obligation for everyone and for the organisation as a whole. To manage all these efforts and to ensure no blind spots are left, organisational procedures, including risk assessment, work post instructions and safety briefings are put in place.

The hazards will all be controlled through appropriate planning by all involved in various areas and departments. All supervisors should be required to prove that their risk assessment/s and planning process have addressed these hazards. The relevant supervisor should, where necessary, consult the director and other relevant personnel in the completion of risk assessments for issues associated with performance hazards and how such hazards will be controlled. Copies of the risk assessment and risk management plan should be made available to all employees and sub-contractors on request. Flag with your Supervisor if any of these issues have not been addressed.

For any sequences involving stunts, fights, aerial, acrobatic work, or any work identified in the Risk Assessment as requiring specialist supervision, an appropriately qualified and experienced Safety Supervisor should be engaged to supervise the set-up of such sequences and, if necessary,

2.1 Risks on stage

At the end of this block, you:

understand the different risks on stage.

We can't stress it enough: a stage is a place full of risks. Some of these risks need a structural approach, but a lot of the risks can be minimised with good practice of the workers on stage. The first step is the awareness of the different risks.

A clean stage is a safe stage

There are a lot of people that need to be on stage during set-up or take down, during rehearsals and during performance. They all need space to work and a clear path to their workspace.

During the set-up, order and organization of all the stuff that is required to build is of the utmost importance. So, **organise your stage**! Bringing materials in and putting them on the right spot will not only improve efficiency, but also improve safety. A clear and organized workspace, even if it is a temporary one, ensures that workers can move around safely. Some simple measures can work miracles. Tool and material cases are lined up on the side of the stage or on the front stage. In this way, you find what you need, you don't have to move cases and there is a clear passageway. Cables are laid immediately on the right spot and out of the walk (or drive) ways. Sets are brought in so that they don't have to be moved several times to build the set. Ideally, they are placed in the right order of use.

Rubbish is removed immediately. Sets that are not in use are stored separately and empty flight cases are stored off stage if possible. A clean stage is a safe stage.

At every moment the **evacuation routes** and the **access to safety equipment** are kept clear. Most emergencies don't wait till you have cleaned the stage!

The above can contradict scenic requirements. Often we want a dirty stage as part of the set. Water surfaces, sand, waste, scrap, stones and more, need to be brought on stage for certain installations, with a naturalistic look. In this case extra measures have to be taken to protect the workers, the equipment and the stage itself.

Pic. 2.1-a-Rubbish

The stage needs to be protected against damage and the **maximum floor load** needs to be checked. This does not only include the risk of the installation when it is finished. The risk for damage when unloading and loading is sometimes even higher. For example, the floor load of a pallet of stones is higher than when the stones are on stage.

We have to avoid that the materials used, **spill** outside of the area where they are used. This is especially true for products that flow and can get to underlying spaces or products that can float in the air.

In most cases there is a stage manager, who is responsible for the organisation on stage. But we can all help in keeping our own work and materials organised.

Lighting conditions

Decent lighting is one of the important elements of safe work. When we are building a performance, good working lights or even daylight help to see what we are doing. But during the performance we are dependent on the stage lighting concept. This means we need lighting on the side stage that is not visible from the house, but that ensures visibility to move and work. This is mostly done with **blue light**. This blue light does not reflect on the black or dark blue legs, but ensures minimal visibility in the wings.

Pic. 2.1-c-Darkness

These limited lighting conditions make that we have to take extra care of obstacles. **Stairs, obstacles and paths are marked** with phosphorescent tape or other high visible material. This does not relieve us from the duty to keep the paths clear and clean.

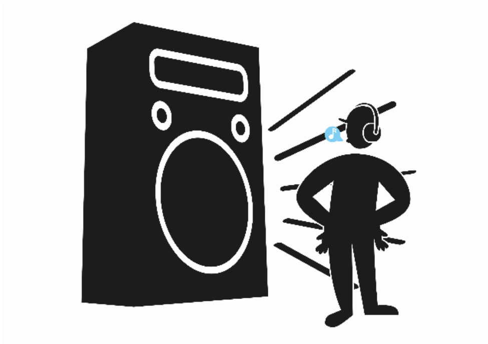
High-risk zones

Some parts of a set-up include dangerous actions. These include working on an open grid or assembling elements above your colleagues. Other risky situations are opening traps, moving elevators or orchestra pits, or moving platforms.

In these cases the danger zone will be **fenced off** and only the required workers will have access to this zone. These people will use the proper personal protection equipment to limit the risk to a minimum. Ideally these activities are scheduled to have a minimum of disturbance for other activities on stage.

During rehearsals or performances, **artistic considerations** will sometimes demand the removal of fences and other security measures. Alternative measures will be taken to improve the visibility of the risk and to minimise the amount of workers in the area. From that moment on, only the people trained for this specific situation and required on stage will be allowed there. The training will deal with all risks and alternative measures taken, based on a specific risk assessment.

Specific activities



Pic. 2.1-b-Noise

Some activities on stage limit the working conditions on stage. Focusing lights requires a dark stage to work accurately. Other activities will need to adapt or to stop during this activity. Ideally this is planned in such a way that it does not delay the other activities.

The **sound check** and the adjustment of the speaker system obviously require the use of the system on maximum capacity. This makes communication on stage impossible and could create high sound levels, which are a potential risk. Ideally, other activities are stopped, especially the ones requiring communication. People on stage should wear hearing protection. Ideally, this is planned in such a way that it does not delay the other activities.

Testing **special effects** always involves some uncertain factors. We can never be completely sure of the exact effect and the corresponding risks before the effect is tested on stage in the exact conditions it will be used in. Extra safety measures, based on a risk assessment, need to be taken to ensure nobody is at risk during the tests.

Ideally, you would like to only have people on stage who are directly involved. But practice proves different in a lot of situations. In that case you need different solutions to ensure safety: A flashlight to prevent you from falling or bumping into something on stage, or ear protection during a sound check.

Under and upper machinery

During setup and takedown, fly bar systems and other rigging equipment will move above your head. This is necessary to get all the sets and equipment in the right position. The operator will **warn** everyone on stage for every movement, especially when the movements reach "heads level". But you also need to **monitor** what is happening above your head yourself.

Other machines like elevators, moving orchestra pits, stage wagons, and loading platforms create a risk on the floor. Even if these machines are supposed to be secured against crushing or hitting people and the areas are supposed to be fenced off, there is always a risk. **Attention to your** (ever changing) **environment** is crucial to avoid accidents.

Securing machines

When **untrained or unauthorised people** can access the control of dangerous machines, these have to be protected against improper use. Fly systems, pyrotechnics, elevators, Genies, electrical equipment, but also the handle of the iron curtain need to be locked. This is often done with a key that locks the emergency button.

Never underestimate the attraction of the magical red button with the “don’t touch” notice to untrained people.

Alcohol, drugs and other products

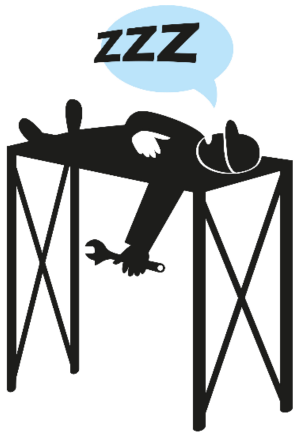
All products and substances that influence your ability to react fast, to think properly and to work accurately should be banned. They form a risk for the others on stage. This ban does not only include the use, but also the effect during work time, based on use in free time. Concretely, we include in this group of products:

- Alcohol
- All kinds of drugs
- Medication with an equal effect (read the medicine leaflet regarding the use of a car or machines)

Most organizations will apply a **zero tolerance** rule, but the minimum is to apply the same rules as when driving a car.

Maximum working hours

There is a maximum reasonable timespan you can work concentrated. Even hard workers have a limit on the time they are able to respond accurately and react promptly. By passing these time limits, they endanger their colleagues.



Pic. 2.1-d-Asleep

A related issue is the **rest time** between shifts. Short nights, with limited hours of sleep will cause you to react slower and less precisely.

Rules about maximum working and rest hours depend from country to country. In some countries exceeding working hours is punishable. The rules are not there to limit our freedom, but to ensure our safety.

Working with third parties

During a set-up, there will probably be other teams working on the same stage. Legally, they are called “third parties”. Before they are allowed to work, they need to be briefed about the local situation. This briefing should include:

- Organization of the work, local regulation
- The tools, machines, etc. used
- The existing procedures
- The use of PPE’s
- Emergency exits, equipment, first aid

The activities also have to be **coordinated**. It has to be clear who is responsible for what part of the job, and which risks the individual parties bring to each other. The coordination also needs to check if all parties are sufficiently competent to fulfil the job safely.

The organiser, as the final responsible, will often **delegate the responsibility** for safety issues to a stage manager. This stage manager conducts the briefing and will have prepared a schedule of who is doing what at what moment on the stage.

When things go wrong

In case of an accident, the first thing you need to do is to take care of yourself. In other words: don’t be a hero, don't put yourself in danger. The next step is to notify a safety responsible (even about near accidents) and to limit the effects of the accident. Avoid exposure of other people to the risk.

The procedures for a specific venue or performance will be part of the **safety briefing**. From this briefing it will become clear who is the responsible person in case of an emergency.

If you have to call the **emergency services** yourself, you need to give them accurate information:

- Your name
- The name of the organization
- Location
- Type of accident and effects
- Amount of victims
- Directions to get to the place

This information will help them to respond as quickly as possible.

What you need to remember

Risks on stage include:

- Unorganised stage
- Limited lighting conditions
- Working above colleagues
- Colleagues working above you
- Fall from height or in stage openings
- High sound levels
- Moving machinery
- Extensive working hours
- High variation in teams or colleagues

To minimise risks, you have to organise your stage and all specific activities. All activities have to be coordinated. It has to be clear who is responsible for what part of the job, and what the risks are. Some activities contradict with the artistic goals, but specific measurements can be taken.

Terms and definitions

- evacuation route
- maximum floor load
- personal protection equipment
- fly bar systems
- rigging equipment
- zero tolerance
- third party
- high-risk zone
- lighting conditions
- phosphoric tape
- blue lights on stage
- stage lighting concept
- specific risk assessment
- sound check
- orchestra pit
- pyrotechnics
- maximum working hours
- rest hours

Rehearsal questions

02.01.01: Tool and material cases can best

a) be put in the middle of the stage.
b) be lined up on the side of the stage or on the front stage.
c) be lined up in the theatre's warehouse.

02.01.02: True/False

- Evacuation routes only need to be clear when the audience enters.

02.01.03: Working lights during performance are mostly

a) yellow.
b) green.
c) blue.

02.01.04: Stairs and other obstacles can be marked for limited lighting situations with

a) phosphorescent tape.
b) fluorescent tape.
c) white tape.

02.01.05: A technician needs to work on an open grid, the measures to protect him are:

a) Closing the door of the grid area.
b) Putting a fence around the opening.
c) Using a harness for the technician.
d) Clearing the stage below.

02.01.06: If you take medication

a) you are not allowed to work, because you are ill.
b) you should check the leaflet to see if it influences your actions.
c) you can operate every machine, because your doctor allows you to work.

02.01.07: A third party

a) is a person employed by another employer.
b) is a person working another shift than you.
c) is a person that is not part of your team.

02.01.08: Name five things you need to tell the emergency services when you call.

02.01.09: True/False

- Only the stage manager is responsible for a clean and safe stage.

02.01.10: True/False

- A dirty stage, even if artistically necessary, must be avoided, also when specific measures will be taken.

2.2 Safety in the audience area

At the end of this block, you:

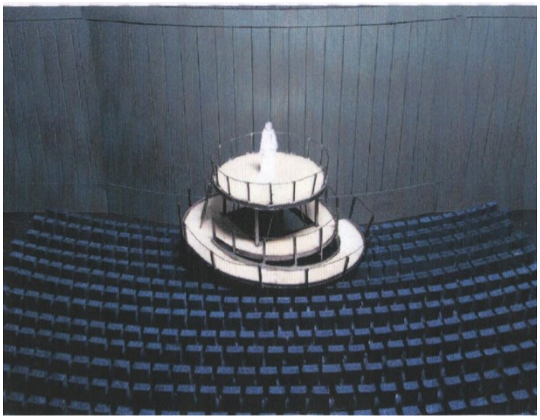
are aware of the risks that can happen to the audience.

The safety of the audience is in the first place the **responsibility** of the heads of guest services, representing the producer (operator of the venue). So there should always be a dialogue with them if you are working in the audience area. Some basic guidelines can help you prevent risks in the audience area.

In some cases, our activities interfere with the presence of the audience. This can be when we install equipment in audience area, build temporary audience provisions or use stage effects that include a risk for the audience members.

Found space

In recent years, there are more and more performances that happen outside the walls of a theatre. Directors and theatre groups make more and more productions at locations like castles, forests, prisons, underground bunkers, et cetera. These are all locations that not have been built as an audience environment. In these cases, the audience area is mostly built by the organiser. So usually, the technical staff is more involved in helping to organise this. They should follow the **same instructions** used in a regular theatre and are limited to the competences for which they have been trained.



Pic. 2.2-1 A set in the audience

Other procedures are created at an **open-air** event or in a **temporary** venue, as well as a different division of responsibilities (third party organizers), other security regulations, additional security forces and a special visitor coordination (intake, escape routes, seats) can be necessary.

Depending on the country, the local fire department or local government will check if everything is organised according regulations, permit and instructions.

Ensure normal and evacuation routes

Moving a large amount of people in an effective and safe way is always a challenge. The group as a whole will act like a herd. They follow each other and push if the speed goes down. This effect increases when passageways get narrower. The members of such a group don't see **obstacles** on the ground as they are too close together. So there is a serious risk of stumbling, tripping or falling. The fallen person will become an obstacle himself, which can be the start of a disaster. All these effects will increase in case of an emergency situation.

To keep the risk to a minimum, we need to ensure that none of the changes we make to an audience space obstructs the audience routes. Cable routes should be planned to make sure that you don't create any tripping risk. Equipment, follow spots, cameras, staff chairs, etc. should be placed out of the **audience routes**. And off course we keep rubbish, empty boxes, etc. out of the space.

Pic. 2.2-2 Television in the audience

The calculation of the **widths of routes** depends on the country or even on the local fire authority. There is always a minimum width based on the amount of people, and depending on the fact if the route is flat, rising or falling, exact minimum figures will be obligatory. When in doubt, inform yourself!

Ensure safety and emergency lighting and symbols are clearly visible

An audience space has two types of safety and emergency lighting. One that is permanently on to allow people to orient themselves in case they need to leave the space during a performance. This could be because they feel ill, have to go to the toilet, … This is what we call **safety lighting**. In most cases, safety lighting is combined with evacuation and safety signs. They can be combined in the fixture or can be lit by it.

Fig. 2.2.a Narrow

In permanent theatres, safety lighting can also include lighting built in the stairs or small downlighters on the walls. These will light risk areas to ensure people can move safely in the dark.

The other type is **emergency lighting** and will light up in case of an emergency. It will allow people to evacuate, even if the electrical system is down. The light intensity of emergency lighting will be higher that the intensity of safety lighting.

Building or adapting an audience facility always requires consultation with the person responsible for the audience safety. In some cases, extra temporary equipment needs to be installed.

Under no circumstances can safety or emergency lighting be **covered or switched off** when audience is in the house. If you see any anomalies or not functioning equipment, contact the safety responsible. If you see possibilities to improve, speak up!

Fall protection

When building temporary constructions which are accessible for the audience, special care must be taken for fall protection. **Railings** have to be put on risers and other high points with a risk for falling. On the ground, slats are placed to stop chairs from falling off. There must also be decent stairs there to access risers.

Effects on stage

When we use effects on stage, they can create a risk for the audience.

- **Sound** levels can become too high in certain areas.
- **Lasers** can damage eyes.
- **Strobes** can trigger epileptic attacks.
- **Smoke** can make people panic.
- **Fire** can make people panic.
- **Fireworks** can damage ears, eyes and cause burns.
- **Audience blinders** can blind your eyes for some time.
- …

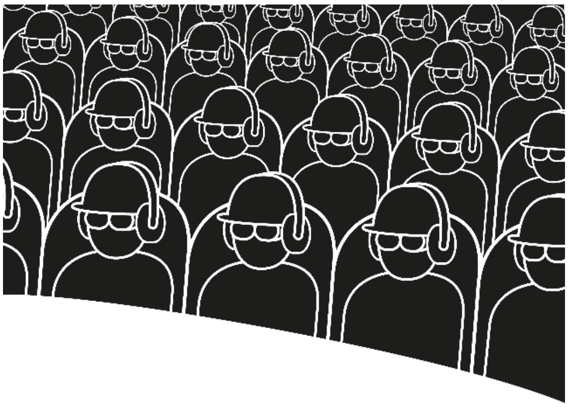


Fig. 2.2.b Safe_audience

In the first place, we will avoid putting the audience at risk. We will protect the audience against coming too close and we limit the effects to a safe level. But some people are more susceptible to these risks. We warn them with **notifications** on the entrance doors.

Special care for specific audience groups

Some audiences need special care. Large groups of children, disabled or elderly people will probably need some **specific measures**. This can be smaller openings in railings, drive on ramps, or provisions for wheelchairs. Depending of the country, local government can ask to have someone, an attendant, taking care of the situation to minimise risks.

Working above audience

In exceptional cases and only when it is unavoidable we will have to work above the audience. For example, when using a follow spot in a house bridge, or when connecting flying actors above the audience. In this case, we will take extra measures and take extra care to avoid falling objects. For example, all people working above the audience will empty their **pockets** and all **tools** or objects will be protected against falling.

Fig. 2.2.c Tarzan

Unsafe areas

If an audience has access to the stage or to service areas, be sure to **lock** access to unsafe places. For example, the grid and bridges, electrical rooms, storage, … Sometimes this can conflict with safe exit routes. In this case, the keys of the emergency doors can be kept in special lockers next to the door.

Procedures

You have to check procedures wherever you work. But especially when you work in the audience area during a performance, you need to check the **procedures** with guest services staff. They will brief you what to do in normal circumstances and in case of evacuation, emergencies, etc..

What you need to remember

- Risks for the audience (effects, falling, working above, temporary builds for audience, …)
- Measures for specific audience groups
- The importance of normal and evacuation routes
- The importance of visibility of safety and emergency lighting and safety symbols
- How to deal with alternative spaces outside a theatre
- In found space audience accommodation needs to be planned

Terms and definitions

- audience area
- found space
- cable route
- safety lighting
- emergency lighting
- fall protection
- service area
- evacuation
- head of guest services
- open air event
- third party organizers
- safety regulations
- audience blinders
- strobes

Rehearsal questions

02.02.01: True/False:

- As long as we keep the minimum width for the audience, we are allowed to put chairs or cameras in pathways.

02.02.02: The light that stays on during performance is called

a) work lights.
a) emergency lights.
b) safety lights.

02.02.03: True/False:

- What we do on stage cannot endanger the audience.

02.02.04: The light that lights up when the power fails is called

a) work lights.
b) emergency lights.
c) safety lights.

02.02.05: True/False

- Also in areas that are not designed for audiences, the same regulations as in theatres should be followed.

02.02.06: True/False

- All audiences need to be treated the same way.

02.02.07: True/False:

- When having effects on stage, they never create a risk for the audience, this is only the case when the effects are in the audience.

2.3 Sustainability

At the end of this block, you:

know how to act in a sustainable way

Sustainability must be a part of our job. We have a responsibility to society and future generations to use as little as possible from the limited resources the earth has. Making performing arts is a very **high-impact sector**. We make sets to only use them a couple of times, transport them over long distances and throw them away later on. If we want to change this pattern, the biggest impact can be made in the **preparing / planning process**. Sets can be made so that they are reusable or recyclable. Touring schemes can be optimised, etc. You can help to protect the environment by following the guidelines below:

Reduce

- Use goods which limit generating waste.
- Reduce the energy consumption.
- Reduce waste by choosing products that have minimal packaging and can be used productively and then recycled.

Re-use

- Re-use containers, packaging or waste products, wherever possible.

Recycle

- Recycle waste material into useable products, wherever possible.

There is a **relationship between safety and sustainability** in production. Not only will sustainable products probably be safe as well (Ex. Paints), but the way of planning and dealing with them also has a lot of similarities. We can apply the principles of risk analysis and the steps to reduce risk to sustainability as well.

In our daily work, we can do small, but important things to reduce our impact on the environment. Some examples:

Use of energy

The best way to reduce energy use is to switch off lights and equipment when not in use. This sounds obvious, but you can gain a lot with just paying some attention to these simple things. Using work lights instead of performance lights will for example reduce the energy consumption by half.

Use of consumables and materials

We use a lot of consumables, for some of them we can find alternatives, others can be recycled. Some examples:

- **Tape** or scotch can be replaced by durable alternatives. They do not only reduce tape consumption but keep the cables clean too.

- **Batteries** can be replaced with reloadable alternatives
- **Colour gels** can be recycled, since most companies will take them back if you ask.
- **Paper** can be recycled or digital paperwork can be introduced.

Selective disposal

Waste can be disposed of selectively, in this way the basic materials can be recycled in a safe and responsible way. Batteries, paint and spray cans are typical examples, but also vinyl tape can be recycled if it is disposed of separately.

Fig. 2.3.a-Accu

Transport

Organising and planning transport can reduce traffic. Simple arrangements like driving together can half the amount of km driven. These are just simple examples. With a bit of awareness for the environment, you can do a lot and motivate other people to do the same.

What you need to remember

- How to make sustainability part if your job.
- Reduce, re-use, recycle and selective disposal
- Use of energy, consumables and materials

Terms and definitions

- sustainability
- reusable
- recyclable
- reduce
- selective disposal
- limited resources

Rehearsal questions

02.03.01: True/False

- Planning is the biggest means to be sustainable in performing arts.

02.03.02: True/False

- The principles of risk analysis and the steps to reduce risk can be used for sustainability.

2.4 Safety Legislation

At the end of this block, you:

- understand the different types of safety documents and their impact.
- are able to identify the applicable legislation.

Fig. 2.4.a Reader

The way we deal with Health, Safety and Sustainability issues is reflected in the **European directives, guidelines and standards**. In this way the European Union wants to guarantee that we can work in the same safe circumstances in different countries.

The **European Directives** set out minimum requirements and fundamental principles, such as the principle of prevention and risk assessment, as well as the responsibilities of employers and employees. A series of **European guidelines** aims to facilitate the implementation of European directives as well as **European standards**, which are adopted by European standardisation organizations.

Member States translate the directives and standards in their legislation and standardisation systems. They are free to adopt stricter rules for the protection of workers when transposing EU directives into national law. Therefore, legal requirements in the field of safety and health at work can vary across EU Member States.

Operational Safety and Health (OSH) "Framework Directive" (89/391/EEC)

The most important is the directive Occupational Safety and Health, the "Framework Directive" (89/391/EEC). This directive describes the general principles of prevention and dealing with health and safety issues.

The Framework Directive also contains basic **obligations for employers and workers**. Nevertheless, the workers' obligations shall not affect the principle of the responsibility of the employer.

The general principles of prevention listed in the directive are the following:

- avoiding risks
- evaluating the risks
- combating the risks at source
- adapting the work to the individual
- adapting to technical progress
- replacing the dangerous by the non- or the less dangerous
- developing a coherent overall prevention policy
- prioritizing collective protective measures (over individual protective measures)
- giving appropriate instructions to the workers

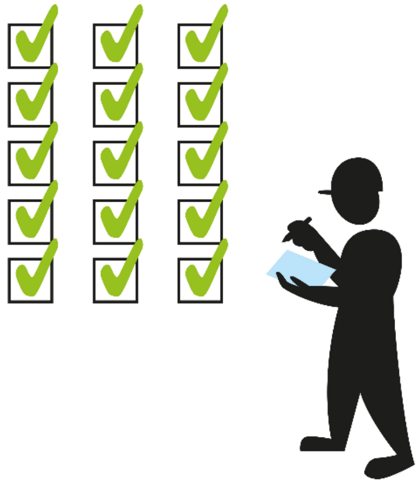


Fig. 2.4.b-b-Documenting

The employers' and workers' obligations are described as follows:

It is the employer's obligation to ensure the safety and health of workers in every aspect related to work and he may not impose financial costs to the workers to achieve this aim. Alike, where an employer enlists competent external services or persons, this shall not discharge him from his responsibilities in this area.

The detailed description of the workers' and employers' obligations can be found in 01.03 Your rights and obligations.

Other directives

Where the framework directive deals with the whole of Health and Safety issues, derived directives deal with **specific issues**. These directives concretise the framework in specific cases, where there is a need for harmonisation of actions.

The directives that influence our sector most are:

Exposure to physical hazards:

- Directive 2003/10/EC – noise

Workplaces, equipment, signs, personal protective equipment:

- Directive 2009/104/EC – use of work equipment
- Directive 92/58/EEC - safety and/or health signs
- Directive 89/656/EEC - use of personal protective equipment
- Directive 89/654/EEC - workplace requirements

Provisions on workload, ergonomic and psychosocial risks:

- Directive 90/269/EEC - manual handling of loads

Guidelines

Guidelines are non-binding documents **helping to comply** with the directives. They collect good practice and interpretation in concrete contexts.

For example there is a guideline “Non-binding guide to good practice for the application of Directive 2003/10/EC of the European Parliament and of the Council on the minimum safety and health requirements regarding the exposure of workers to the risks arising from physical agents (Noise)“. In Chapter 8, “The Music and Entertainment Sectors” we find guidance on how to apply the directive on sound in our specific case.

Related documents

Within the EU there are also directives dealing with **other issues that influence Health, Safety and Sustainability** indirectly. For example, the directives on bringing equipment on the market will regulate what requirements have to be fulfilled, how the supplier needs to document the use, etc.

Following directives have a direct impact on our sector:

- Directive 2001/95 EC - product safety
- Directive 2006/95/EC - electrical equipment
- Directive 2006/42/EC - new machinery directive
- Directive 89/686/EEC - personal protective equipment

Standards

Harmonised standards, or standards for short make the directives concrete for a specific sector or type of equipment. The standards help manufacturers to build equipment that meets the essential requirements of products established by the directives. If the equipment meets the standard, it can be used in all EU countries. Member States must accept the free movement of such products.

A ‘harmonised standard’ is a standard adopted by one of the **European standards organisations** – European Committee for Standardization (CEN), European Committee for Electrotechnical Standardization (CENELEC) and European Telecommunications Standards Institute (ETSI).

Most countries will translate the harmonized standard in their own standardization system. In reality, they keep the same content and number and add it to their own system. For example the NEN EN 13772, DIN EN 13772 and BS EN 13772 are exactly the **same standards** as the European EN 13772. Standards are not legislation and every manufacturer is free to follow them or not. But if they don’t follow them, they have to prove they meet the European legislation.

When legislation does not provide the solution

Alternative or substitute measures in case we cannot follow the legislation

- We can look at what the **result** should be, what the legislator has meant
- We can take other **measures** that have the same result.

For example:

- Open fire on stage is forbidden, the reason is we don't want a theatre on fire.
- We can organize ourselves so that the result is the same level of safety.

Local legislation and rules

On top of national and EU legislation, some **local administrations**, fire departments or insurance companies can impose stricter rules. Most performance spaces will have house rules and house procedures, too. Inform yourself about this before you start working.

Safety vs liability

Employers and safety responsibles stress the importance of **documenting safety**. The reason for this is that they want to cover themselves and their organisation in case something happens. When something happens, an investigation will search for who is **liable**. At that moment you need to be able to prove all the actions that have been conducted in the safety process. So documenting your own actions properly is also in your interest. It proves that you have done what you were supposed to for your and your colleagues' safety. But we should never forget that paperwork cannot replace safe work.

What you need to remember

- The principles behind the Operational Safety and Health (OSH) "Framework Directive"
- The difference between directives, guidelines and standards

Terms and definitions

- directive
- guideline
- good practice
- harmonized standard
- legislation
- liability

Rehearsal questions

02.04.01: True/False

- A country can put less strict rules in their legislation than the European directives.

02.04.02: If a national standard contains EN in its name, this means

a) the standard is in English.
b) the standard is a European standard.
c) the standard is a local, regional or national standard.

02.04.03: True/False

- The way you deal with health and safety in your country is derived from the OSH.

02.04.04: True/False

- A European guideline is not binding, in other words, you don't have to follow it.

2.5 Danger signs

At the end of this block, you:

- recognise the danger symbols.

Danger signs indicate dangerous substances or situations. They are put on doors, work places, equipment or packaging of products. They help you to identify these riskful situations or products.

The signs are **yellow triangles with a black border and a black drawing**.

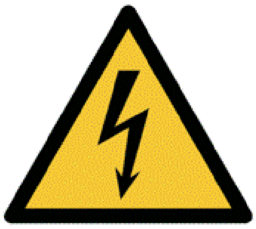
General danger

This sign indicates a **non-specified danger**.

Ico. 2.5.1 general danger

Electricity danger

This sign indicates danger for electricity. It means there are (touchable) **electrical connections present.** The sign is mostly combined with an indication of the tension.



Ico. 2.5.2 electricity danger

Hanging loads

This sign indicates danger for hanging or suspended loads. This can be for example **trusses or fly bars**.

Ico. 2.5.3 hanging loads

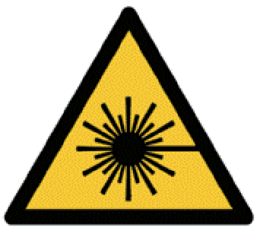
Forklift and transport vehicles

This sign indicates danger of moving forklifts or transport vehicles. It means you have to take care to not be run over when walking.

Ico. 2.5.4 forklift and transport vehicles

Laser beam

This sign indicates harmful laser beams are present.



Ico. 2.5.5 laser beam

Optical radiation

This sign indicates danger for optical radiation. This can be high-intensity bulbs, for example.

Ico. 2.5.6 optical radiation

Toxic

This sign indicates the presence of toxic material.

Ico. 2.5.7 toxic

Corrosive

This sign indicates the presence of corrosive material.

Ico. 2.5.8 corrosive

Flammable

This sign indicates the presence of flammable material.

Ico. 2.5.9 flammable

Oxidiser

This sign indicates the presence of oxidising material.

Ico. 2.5.10 oxidiser

Explosion danger

This sign indicates the presence of explosive material.

Ico. 2.5.11 explosion danger

Markings

Aside from the danger signs, sometimes black and yellow tape is used as well to mark **paths** that need to be kept free or to mark **stairs**. In low-level lighting situations, stairs can also be marked with **phosphorescent tape** (glow in the dark).

Pic. 2.5.1 black and yellow tape

To **close off areas**, often red and white ribbon is used.

Pic. 2.5.2 Red and white ribbon

What you need to remember

- Danger signs indicate dangerous substances or situations. The signs are yellow triangles with a black border and a black drawing.

Terms and definitions

- general danger
- electricity danger
- hanging loads
- forklift and transport vehicles
- laser beam
- optical radiation
- toxic
- corrosive
- flammable
- oxidiser
- explosion danger

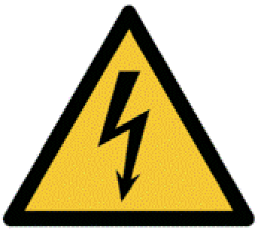
Rehearsal questions

02.05.01: Match the signs with where you find them

1. stage
2. pyrotechnics
3. laser
4. electric cabinet

A

B



C

D

02.05.02: This sign means:

a) oxidising
b) flammable
c) explosive

02.05.03: This sign can be found on

a) pyrotechnics
b) spotlights
c) electrical drills

2.6 Prohibition signs

At the end of this block, you:

recognise the prohibition symbols.

Prohibition signs indicate forbidden behaviour likely to cause a risk to health or safety. They show only what or who is forbidden. The signs are put on doors, work places, equipment or packaging of products. The signs are a **red circular band with diagonal cross bar on a white background**. The black symbol within the circle indicates the forbidden action.

General prohibition

This sign indicates a general prohibition. It will be combined with text or other information.

Ico. 2.6.1 general prohibition

No smoking

This sign indicates a smoking prohibition.

Ico. 2.6.2 No smoking

No open fire

This sign indicates a prohibition for open fire and smoking.

Ico. 2.6.3 No open fire

Do not extinguish with water

This sign indicates a prohibition to extinguish something with water.

Ico. 2.6.4 Do not extinguish with water

Do not use elevator when fire

This sign indicates a prohibition to use the elevator in case of fire.

Ico. 2.6.5 Do not use elevator when fire

No heavy loads

This sign indicates storing heavy loads is not allowed.

Ico. 2.6.6 No heavy loads

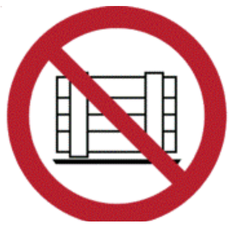
No forklift

This sign indicates no forklifts and other industrial vehicles are allowed.

Ico. 2.6.7 No forklift

No obstructions

This sign indicates to keep the area free of obstacles.



Ico. 2.6.8 No obstructions

What you need to remember

- Prohibition signs indicate forbidden behaviour. The signs are a red circular band with diagonal cross bar on a white background. The black symbol within the circle indicates the forbidden action.

Terms and definitions

- general prohibition
- no smoking
- no open fire
- do not extinguish with water
- do not use elevator when fire
- no heavy loads
- no forklift
- no obstructions

Rehearsal questions

02.06.01: This sign means

a) Do not put equipment on hatch
b) Do not put heavy loads on floor
c) Do not push emergency button

02.06.02: Match

1. Do not use elevator
2. Do not extinguish with water
3. No vehicles allowed

A

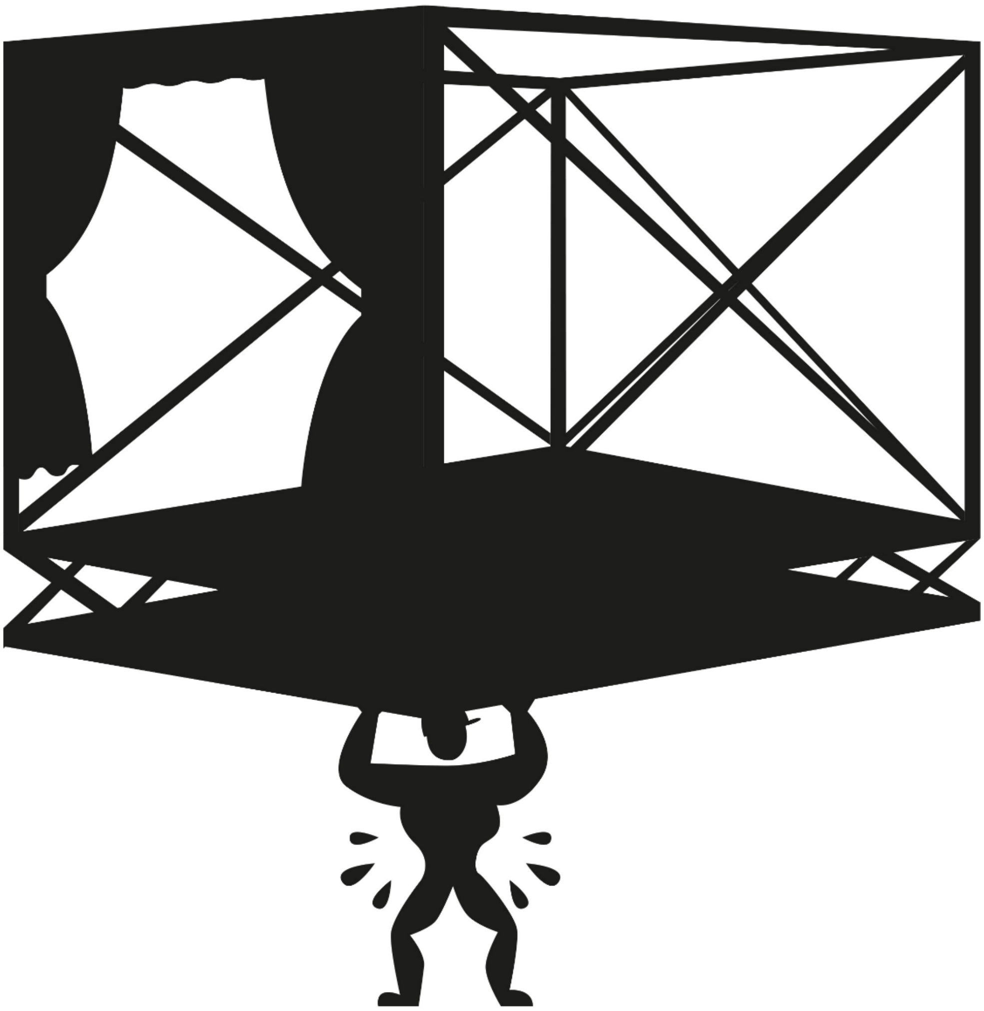
B

C

02.06.03: This sign means

a) Do not light cigarettes
b) Do not use open fire
c) Do not extinguish with water

3 Work ergonomically



TO WORK ERGONOMICALLY, YOU MUST:

Apply ergonomic principles in the organization of the workplace and do so while manually handling equipment and materials.

This means you master following skills:

- Identifies ergonomic risks
- Organises workplace ergonomically
- Applies the ergonomic principles and methods while lifting, carrying or moving heavy or unpractical loads
- Uses the right equipment when lifting, carrying or moving heavy objects
- Asks for help for tasks they can't carry out on their own
- Communicates with colleagues while lifting, carrying or moving objects

You master following knowledge:

- Risks as result of manual handling
- Ergonomic methods
- Equipment for lifting, carrying or moving

You have following attitudes:

- Awareness of long term impact on personal health

When working on stage with tight deadlines, lots of equipment, machinery, and heavy materials, it is important to always think about your body and health. It is easy to lift something that is a little bit too heavy now to save time. At this moment, it is a solution, but doing this a lot can cause a health risk on the long term. This is only one example of many things that can happen when working on stage. Of course this also applies to transporting materials, lifting, manual handling and using electric equipment.

Ergonomics deals with the relation between body and work environment. In other words, how do we organise our work and workspace, how do we use our body and how does this combination affect our health and safety.

Ergonomics has a secondary effect apart from protecting health and improving the work environment. It will also improve the **efficiency** of the work process. This is a nice extra and a stimulant to apply the guidelines for ergonomic work.

Fig. 2.6.a -a-Stage-on-back

Ergonomics focuses on **long-term health risks**. These are risks that do not cause an immediate effect or accident, but cause damage that occurs only after a while. Typical injuries are spinal injuries or low back pain. These injuries do not occur on the moment the damage is done, but (sometimes years) later.

Ergonomics includes more than lifting and handling objects or the arrangement of the workplace. It also includes **stress factors** as a result of the work environment. These stress factors cause short-term as well as long-term effects.

Identify ergonomic risks

Identifying and assessing ergonomic risks is a continuous process that is done on several levels.

Before you lift something, you need to assess **the object** you want to move. Some questions can help with this assessment:

- How much does it weigh?
- Is it easy to handle?
- What would be the best way to lift it?
- Can tools be used to make it easier to handle?
- Can I handle it alone or do I need help?
- Where does it have to go?
- Are there any obstacles in the way?

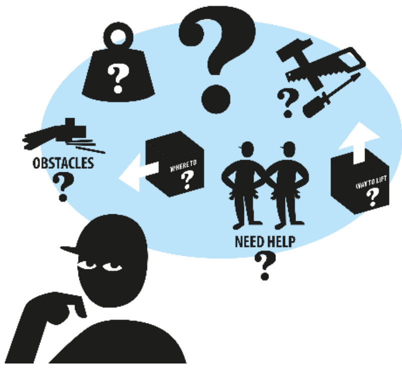


Fig. 2.6--b-Questions

This list reflects the questions most people will ask themselves unknowingly when they need to move an object. Becoming more aware of these questions will help you find the best solution.

A less direct form of assessment concerns the way you (and your team) **organise** yourself and your environment. Questions here can be:

- Where do we put flight cases when they come in?
- What is the best order to load or unload?
- What do we need to tackle the work more comfortably?
- Where do we put control desks?
- How do we limit stress factors?

Some assessment needs to be done in advance, during the designing/planning phase of the production. This is mostly out of our reach, but we can help by giving feedback and proposing improvements. Designers and production **planners** can ask themselves some questions, too:

- Are the objects easy to handle/manipulate?
- Do they have handgrips on a proper height?
- What is the weight of each object?
- How will the equipment be packed?
- Can flight cases be placed in reach of where the content is needed?
- Can we avoid lifting of content or objects?
- Can we develop dollies or chariots to improve handling?

Venues can look at the entrance way and the road to where equipment needs to go. Some questions can be:

- Can equipment be transported on wheels?
- Are there slippery or bumpy surfaces?
- Can the truck floor be on the same height as the loading dock?
- Is there equipment or provisions to move equipment to difficult to reach places like mixing booths?

The answers to all these questions are the first step to improve the organisation of the workspace, to choose the right method or to find the right equipment.

Organise Space

In traditional work environments, the organisation of the workspace is done in advance by engineers. In performing arts or events, we (partly) develop our own (temporary) environment. We start from an empty space and organise it. We build a temporary warehouse, a temporary office, a temporary control booth, etc. This has the advantage that we can adapt it to the best ergonomic standards, but we need to think about them.

Fig. 2.6-c-Magician

Organising the stage starts with unloading the truck. If we bring in equipment, cables, scenery, etc. and we put them directly on the spot where they are needed, we can avoid a lot of moving and lifting. If we **organise** our cases in such a way that we can easily take what we need and if the cases are placed close to where we need the content, we can avoid a lot of walking and moving.

In some cases, all lifting or unpacking can be avoided. A roller frame for a mixing desk brings the desk on the right level without any lifting. Putting hoists in their case under the hoisting point, allows them to lift themselves. Multi-cables can remain rolled up in a case and be placed under the position where they will be needed. This way, they can unroll themselves. All of these examples improve efficiency.

During **setup**, we will organise several workstations. Some thoughts on how we can improve these:

- When we need to provide working tables or operating booths, we can choose the right height of the work surface and use the proper chairs.
- We can provide enough space to move. When using flight cases as tables for example, leg space can be a problem.
- We can avoid workstations being used as passageways.
- We can protect against accidental activation of equipment or controls.
- We can ensure the technician, prop master, etc. has all he needs within reach.
- We can make sure the operator has a good position, from where he can see what has to be operated but also do the operating itself, without moving or turning.

Behave

Organizing the space only improves one part of the ergonomic system. The other part is you, or more specifically, how you behave. You have to learn, practise and use proper lifting techniques. And you have to organise your work in an ergonomic way.

Manual handling techniques

The best way to lift or handle objects manually is to **avoid** it when possible. If there is another way, by using equipment, tools or methods, use these. Doing so will keep your body ready for the moments you can't avoid manual handling.

A second piece of advice is to **take care of your body**. Warm up your body before you start. Just like athletes we need our muscles to be warmed up before we start. It only takes a couple of minutes. Some simple exercises can protect your muscles against serious injuries.

There are a lot of different situations in which we lift, pull or push. Each of them needs a specific lifting approach. But there are some basic principles that apply to all situations:

- **Use your legs**, not your back. Lifting with your knees and a straight back is a lot safer.
- Keep the weight **as close as possible to your gravity point**. Your backbone can bear the maximum load this way.
- **Balance the load**. There is a lot less stress on your back if you carry half of the weight in each hand.
- Keep your **back in a straight line**, avoid movements that twist your spine.

- Avoid or limit **dynamic forces**. These increase the forces on your body.
- Ask **help** if an object is too heavy or unpractical to lift on your own.
- **Communicate** with your colleagues when lifting together. This avoids that one person suddenly carries all the weight.
- Use the right **shoes**, they will minimize shocks on your body.
- Practise and use proper **sitting** positions.

The different lifting, pulling and pushing methods are explained in the chapter "ergonomic methods". You need to train and maintain them.

A last piece of advice is to listen to your body, and to know your limits. You don't need to prove yourself. No one gains from you lifting a huge weight once and being injured for the rest of your life.

Organise Work

There's an old Dutch saying that goes: "**the legs must pay for what the head forgets**". This is absolutely true on stage. If you organise yourself well, you can limit the amount of walking to a minimum. We already mentioned that the organization of the stage is an important factor. But you can improve even further by organizing yourself.

Some examples will make this clear:

- Using the right equipment will avoid lifting and handling.
- Preparing your own workspace before starting will improve efficiency. When everything is in place, you work twice as fast.
- Let your materials move with you. A spot rack on wheels can move with you when hanging lights, reducing the time you walk and carry spotlights to a minimum.

Another important goal for your individual organization is limiting stress factors. Some examples:

- Avoid testing sound and light at the same time.
- Use an intercom to communicate. During set up, it avoids yelling and distracting other people.
- When using an intercom during performance, limit the information over the channel. This avoids an information overload for operators.
- Limit passing in critical places during the show.
- Organise the backstage for comfort, this reduces stress.
- Know when to ask questions. Asking a question during intense activity creates stress. If it can wait, find a good moment later.

Use Equipment and Tools

Using tools and equipment to move objects, avoids **physical stress** on the body. There is a wide variety of tools and equipment available on the market. These are not always adapted to the specific context and situation of performing arts or events. Because of this, **specific tools** have been developed over the years to facilitate our job. We have created an overview of the different tools available and their use in the chapter "Equipment for lifting, carrying or moving".

Of course, tools only help if you use them. Too often we see a strange kind of **laziness**: People handle something manually while a tool is available some steps away. Habits and laziness can be changed by training and consistent use.

Using tools and equipment can create **new risks**. Avoiding manual handling probably increases pushing or pulling. The objects need to be put on the tool or in the flight case. This means it is essential to train how to use them in a proper way. Only then, we can have maximum impact on the working conditions.

Propose Improvement

No situation is perfect. New issues will appear when you are working. The best person to identify them is the one who works within the situation. In some cases you will also see possible improvements yourself.

It is part of your job to give feedback to the person responsible for the production. Doing so will improve the situation in the future.

Terms and definitions

- ergonomics
- ergonomic risk
- ergonomic principles
- long-term health risk
- stress factor
- manual handling methods
- lifting methods

3.1 Risks as result of manual handling

At the end of this block, you

know the physical risks as a result of manual handling.

Risks as result of manual handling and workplace organization

It is important to realise that the **weight** of objects and **the way we handle them** are not the only causes of damage, but that the **frequency and repetitiveness** of the work can harm us as well. Handling hundreds of small items can cause as much damage as one heavy weight. The act of handling objects in a working environment can cause different types of damage to the human body.

We look into tree main categories: Short-term damage, chronic damage and stress-related damage. An example of the different types can be illustrated as follows:

- **Short-term damage**: you hurt your muscles lifting motors in flight cases in a truck that is too high.
- **Chronic damage**: back problems due to lifting motors in the truck every day, for instance when working in the warehouse of a rental company.
- **Stress related issues**: back problems due moving motors every day while having too little time.

We do not take into account the damage to the working environment or objects used. Dropping or breaking stuff is a secondary effect in most cases. This is important in the whole of a safe environment, but not in this specific chapter.

Short-term damage

Short-term damage to the body is damage that can be **easily related to a specific cause**. The damage can be acute, like a muscle tear or an inguinal hernia from lifting heavy weights or an ankle sprain from slipping or falling. The damage can also be delayed. It doesn't occur directly after the cause, but there is a clear relation: a local muscle fatigue with pain sensation; a general fatigue or reduced coordination of movements are typical examples. With the right treatment the damage will go away.

Chronic damage

For chronic damage, it is more **difficult to relate the damage to a concrete cause**. The damage is mostly a result of long time exposure. It is wear and tear, damage that comes by (mis)using and overloading specific elements of the body over the years. This means not only the weight of the loads or the way of manipulating is important, but also the frequency of the actions. Lifting one heavy 3 phase cable or multi-cable can seem like a risk, but in reality lifting a smaller 16 A cable 50 times can be a larger risk if not done properly.

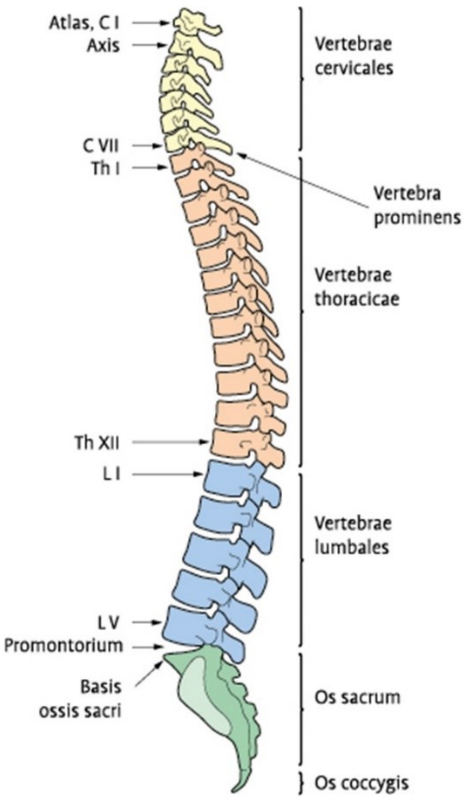
Often, the damage (pain) is **not noticed on the spot**, but later. For example when body is relaxed. This is the typical technicians holyday disease. Or the result, the pain, can be triggered by a small insignificant movement that is “the straw that broke the camel’s back”. A typical example is tying your shoes in the dressing room before you leave for home. Another typical example, that combines both phenomena, is getting out of bed in the morning and making a “wrong movement”.

In all these cases, **the action that triggers the pain is not the cause of the damage**. This cause lays further back in time, sometimes spread over several years of misuse and overloading.

Construction of the spine

Bone structure of the spine with 7 cervical vertebrae, 12 thoracic vertebrae, 5 lumbar vertebrae, the sacrum (5 fused cruciate vertebrae) and coccyx (3-6 rudimentary coccyx).

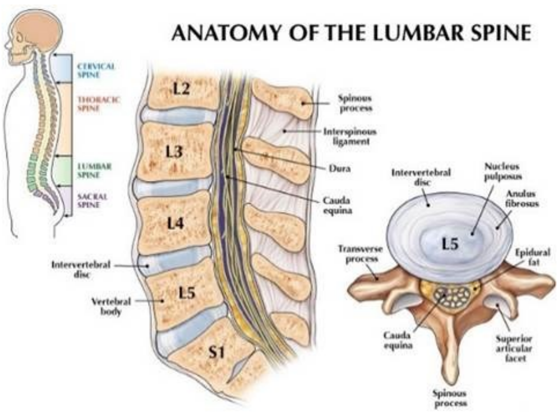
Chronic damage can occur on knees, hips or shoulders, but the most common and most complicated damage in theatre will be back injuries. To understand these injuries, we need some **basic understanding of the construction** of the spinal column.



Pic.3.1.1The vertebral column

The vertebral column, also called the backbone, is made up of **33 vertebrae** that are separated by spongy disks and classified into four distinct areas. The cervical area consists of seven bony parts in the neck. It is the smallest, as it only has to carry about 5 kg. The thoracic spine consists of twelve bony parts in the back area. The lumbar spine consists of five bony segments in the lower back area. This is the largest. It needs to carry the whole body weight, but also has to be very flexible and resist enormous forces. The final parts are the five sacral bones (fused into one bone, the sacrum) and four coccygeal bones (fused into one bone, the coccyx).

In between the vertebral bodies (the bones) are the **intervertebral disks**. They have two main functions: They absorb shocks and they allow movement. The shocks can come from above, for example as a result of lifting, or from below, for example as a result of walking. Allowing enough movement guarantees the needed flexibility of the spine.



Pic. 3.1.2 Anatomy of the lumbar spine

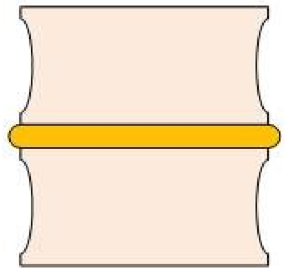
The intervertebral disks are composed of two parts. You could compare them to a jelly donut. A tough outer ring of fibrous tissue called the anulus fibrosis and an inside that is more gelatinous or soft material, called the nucleus pulposus. When the pressure on the disks is lower than 80 kg (for male adults; when we lay down), they will absorb fluids. When the pressure is higher (sit or stand) the fluids are released. This exchange of fluids is essential for the condition of the disks (This means laying down permanently is as bad as standing the whole time). After laying down long, the disk becomes elastic and hard. After standing up long the disk becomes soft. The ideal situation is in between, with maximum elasticity.

The bones are connected to each other with **ligaments and muscles**. The spinal cord passes through the holes in the vertebral bodies. The spinal cord is the main nerve canal that connects the brain with the body. From there spinal nerves go to the body.

What happens when we move?

In **normal circumstances**, when we stand up for example, the bodies of the spine are in a straight line. The disks support the forces on the spine and the bodies equally.

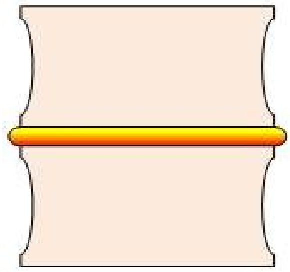
This is the optimal situation. The disks can function as shock absorbers.



Pic. 3.1.3 optimal situation for the spinal disk

When we **carry heavy loads**, we will increase the forces on the disks. The disks will be compressed. The fluid in the disks will be pressed out and the disk becomes harder.

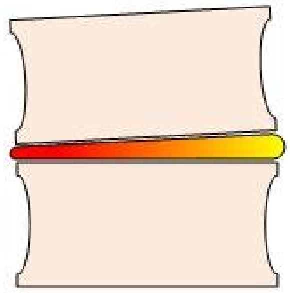
But as long they are in a straight line with the bodies, and the pressure is not to high, they will support and absorb the shocks. When released, the disks go back to their original position.



Pic.03.1.4: situation for the spinal disk with heavy load

When we **bend over**, the spine needs to curve. The disk is now compressed on the front side. This creates an uneven load on the disks. This uneven load limits the shock absorbing capacity and can speed up the degeneration of the disk.

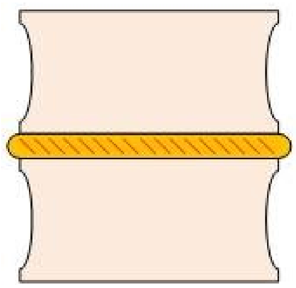
A second effect is that the upper body weight needs compensation to keep in balance. This compensation comes from the back muscles.



Pic 3.1.5: situation for the spinal disk bent over

Bending backwards will create a similar effect on the disks. But there is a second effect. On the back of the spine, there are joints. Between these joints there is cartilage to protect them. Bending backwards will compress the cartilage. The parts will rub over each other. This can create damage to this cartilage.

When we twist our spine, the bodies need to rotate against each other. This creates torsion in the disk. This torsion can speed up the occurrence of small cracks and fissures in the disk.

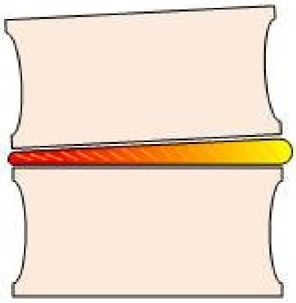


Pic 3.1.6: situation for the spinal disk bending backwards

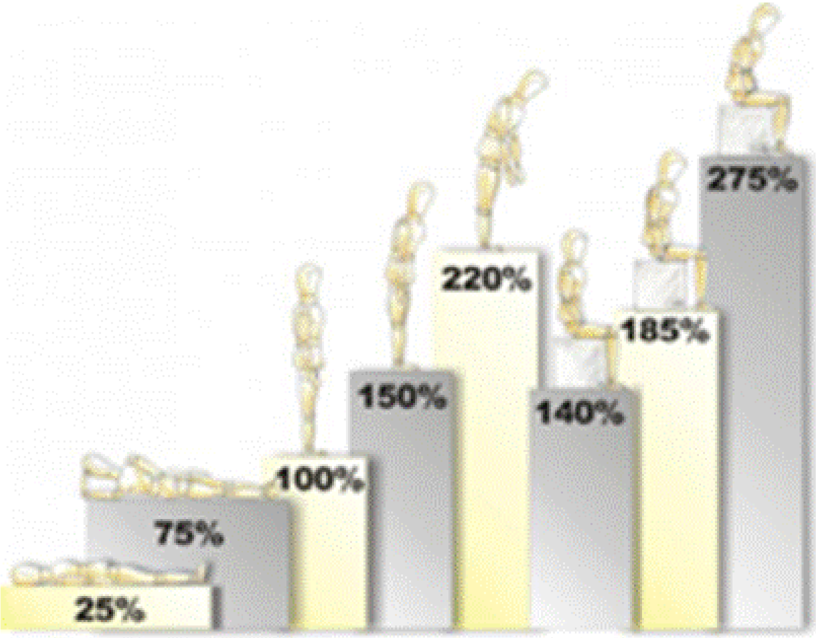
A combination of **twisting and bending** will cause a combination of the above factors. This occurs for example when you pick up something from the ground on your left and put it on a table to your right.

The combination of torsion and unevenly pressure of the disk, often combined with large forces is considered the highest risk for back damage.

The table below shows the stress on the disks in different body positions.



Pic. 3.1.7: situation for the spinal disk with combination of torsion and unevenly pressure

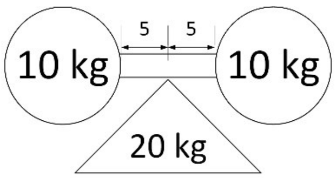


Dia. 3.1.1 Stress on the disks in different body positions

Some mechanics

Of course, the impact will depend a lot on the forces that are impacting the spine. These forces are a result of two elements. The first element is the **actual weight** of the object carried. A heavy object will obviously create more force than a light one.

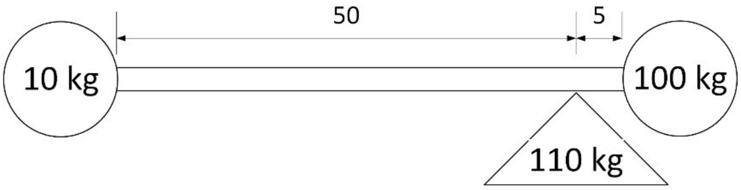
But the second element is much more important. This is **the place of the object in relation with the spine**. The closer the object is to the spine, the less force it will create. We can explain this with simple mechanics.



Dia. 3.1.2 balance

When we lift something, the downward force of the object is **compensated** with a downward force from the back muscles. These two forces "balance" on the spine.

When we lift an object close to the spine, the distance between the **gravity point** of the object and the attachment point of the back muscle will be almost equal. This means that for lifting an object of 10 kg, there will be a force of the back muscle reflecting 10 kg as well. The force on the spine will be equal to a weight of 20 kg.



Dia. 3.1.3 lift object with arm's length

When we lift the same object, but now **at arm's length**, the "load arm" will become longer while the "force arm" will stay the same. To lift the same weight of 10 kg, the force of the back muscle will need to be ten times as high. The force on the spine will increase with 450 %!

This effect becomes even larger when we bend over to reach something. Not only will the "load arm" become longer, we also need to take in account the weight of the upper body that increases the total weight.

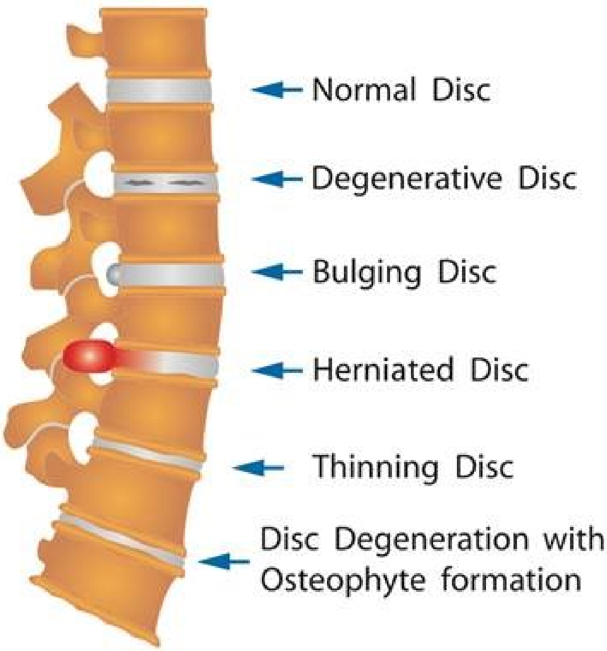
The above is the basic background for all manual handling and lifting techniques. Keeping the weights close to the body will limit the force on the back muscles, the spine and especially the disks.

What can go wrong?

First of all, the vertebral disks also **degenerate** in normal circumstances by aging. After the 30th year the disks will show less fluid absorption, and small cracks and fissures. They will become less elastic and will start thinning. They will have less carrying capacity.

Heavy forces, abuse and in some cases specific injuries speed up this process. Using the right techniques and methods will postpone the effects of degeneration.

A secondary effect of the thinning of the disks is increased wearing of the cartilage of the spinal bodies. As the disks get thinner, the cartilage starts rubbing and wears of.



Pic. 3.1.8: Vertebral disks degenerate

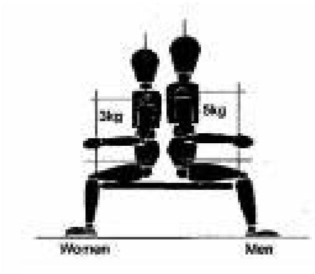
In some cases a disk can start **bulging out**. As the disk gets less strong and flatter, it will bulge out of its normal proportions under compression. In the worst case, the disk gets in contact with the nerves, which can be very painful.

When the disk bursts open and spills the jelly like fluid this can impact the spinal nerves. The jelly will push on the nerves, which causes a continuous pain. We call this a **hernia**.

Acceptable weight limits

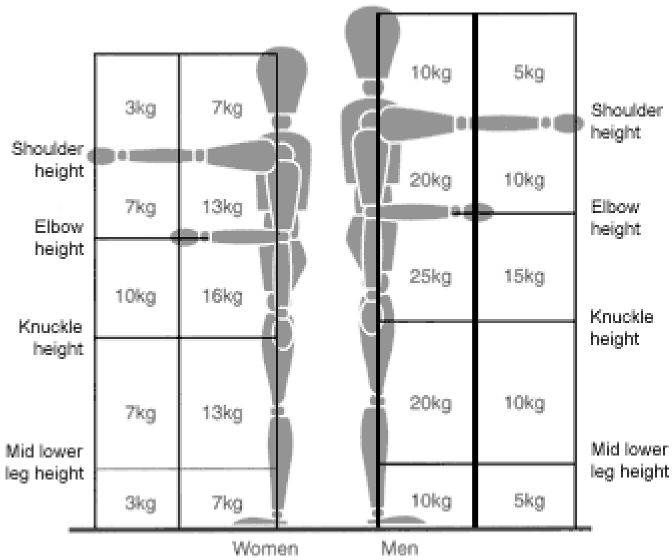
Based on the above knowledge, experts have developed limits to what we can manipulate without risk for early chronic damage. We call this the **NIOSH Lifting Equation** (National Institute for Occupational Safety and Health). It takes in account the following elements:

- Horizontal location of the object in relation to the body
- Vertical location of the object in relation to the floor
- Distance the object is moved vertically
- Asymmetry angle or twisting requirement
- Frequency and duration of lifting activity
- Coupling or quality of the worker's grip on the object



Dia. 3.1.4 acceptable loads 01

A simplified, but easier to use, table shows acceptable loads in different positions. This table does not take frequency or grip into account, but it gives an indication of the limits.



Dia. 3.1.5 acceptable loads 02

Stress

Apart from physical causes, there are indications that psychological causes can also be at the origin of back problems in the workplace. These can be divided into two types. On the one hand there are factors like **monotonous work** or **unhappiness** with the work situation. This can happen for example when working in storage, without ever seeing the result of the work place.

On the other hand, there are **stress factors directly related to the work environment**. These factors can be sensory or external.

Sensory stress or sensory overload is a result of the amount of information that needs to be processed. When too much information needs to be processed in a short time and there are continuous deadlines, a person meets his limits. This can result in reduced visual acuity, slowing down, slower response times or disorganised behaviour. It is clear that these effects will be a factor in accidents.

External stress factors like noise, smoke, … can increase this effect.

The effects of stress are hard to measure and bound to the individual. But avoiding an information overflow, organizing the control booths to be able to focus and limiting external stress will improve the health and safety anyway.

What you need to remember

- Causes of damage are not only due to weight. The frequency and repetitiveness of the work can do harm as well. There are three main categories:
- Short-term damage: can be easily related to a specific cause.
- Chronic damage: more difficult to relate the damage to a concrete cause, wear and tear of the body.
- Stress-related damage: two types:
- 1 factors like monotonous work or unhappiness with the work situation.
- 2 stress factors directly related to the work environment.
- The function of the spinal disks.
- The relation of the impact on the spine and the distance to the object.
- The acceptable load limits.

Terms and definitions

- short-term damage
- chronic damage
- vertebral column / backbone
- intervertebral disk
- NIOSH Lifting Equation
- acceptable weight limit
- stress

Rehearsal questions

03.01.01: True/False

- A cause for damage to the body is only manual handling of weight.

03.01.02: True/False

- Chronic damage is caused by stress.

03.01.03: True/False

- Chronic damage can be a result after years of working.

03.01.04: True/False

- The intervertebral disks absorb shocks and they allow movement.

03.01.05: True/False

- Torsion and uneven pressure of the disk, combined with large forces, will be absorbed well without damage to the intervertebral disks.

03.01.06: True/False

- Frequency and duration of lifting activity is not an element of the acceptable weight limits.

03.01.07: True/False

- Monotonous work, unhappiness with the work situation, sensory stress, sensory overload and external factors can all lead to stress.

3.2 Ergonomical methods

Before you start, you should read the "risks as a result of manual handling" chapter.

At the end of this block, you:

Are able to apply the different ergonomic lifting, pulling and pushing techniques..

Ergonomic methods describe the way we lift, move, push, pull,… equipment and other loads to avoid the risks of manual handling like acute and chronic damage to our body. They are part of a larger whole that ensures an ergonomic work environment. This environment includes the way work is organised, the physical environment, and the tools we use to move equipment.

It is important to realize that not only the **weight and shape** of the load influences the risk for damage, but also the **frequency** of the work. For example moving one heavy 3 phase cable or a multi-cable can cause as much stress on your body as moving 50 small schuko cables one by one. On the other hand, peak loads can have impact too, even if the average daily load is within the limits.

Obstacles being in your way when moving can also influence the impact on your body. Slipping surfaces, rakes, bumps, etc. influence the amount of force needed and therefore the physical impact on the body. A stressful environment will have an influence too. As an individual worker, you have limited impact on these situations, but you can take them into account when planning your work and you can notify the person responsible for safety.

Activities that look harmless and relaxed can cause injuries to your body if the working environment is not adapted. Sitting in a cramped operating position, the height differences and relation between equipment you use, spinal rotation and torsion to oversee your work, and long repetitive movements, like while using a mouse, can cause back, joint, or muscular damage.

This is equally true for not using the proper **personal protection equipment** (PPE) when working. Using the right shoes will minimize shocks on your body, using proper gloves will ensure better grip,...

Foresee and prepare

To avoid all misunderstandings, this is not about procedures, but about **common sense** applied on the spot. Foreseeing possible problems when the load is still in a stable position is better than realizing half way that you have a problem while you are holding the load in a very uncomfortable situation. We all know an example of getting stuck in the turn of a stairway with a box that is slightly too big.

So **before you start**, check the route.

- Are all doors open?
- Are door openings wide enough?
- Are door openings high enough?
- Are there stairs or slopes in the path?
- Are there any obstacles in the way?
- Is there enough room to pass and turn? (Measure this.)
- Is there a place to rest halfway?
- …

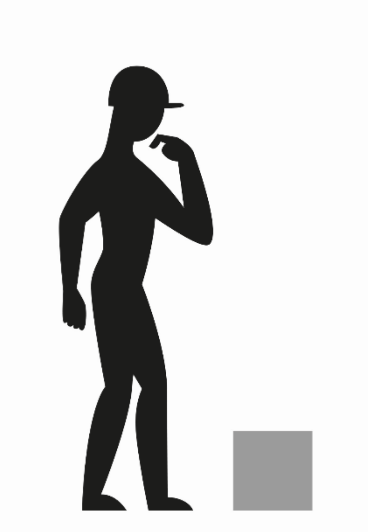


Fig. 3.2-a think before you start

And consider **how** the load is best lifted or moved.

- Do you know the weight? (Is it written on the load?)
- Do you know where it has to be used on the stage?
- Where is the load to be placed?
- Do you need help?
- Can you use tools?
- What is the best way to lift?
- …

Avoid

The best way to lift is to avoid lifting. The best way to pull is to avoid pulling. Everything that can be moved without lifting, pushing or pulling the weight improves the situation. This can include the use of appropriate tools, but also the use of tipping techniques. When **tipping**, we leave the weight on the ground, and use the natural turning point of the object.

A typical example of this is tipping flight cases. The case is lifted on one side, but the weight stays mainly on the ground. To put heavy flight cases back on their caster wheels, the wheels can be put inward. This changes the tipping point and avoids a sudden drop by the wheels turning when charged. Some flight cases are made especially for tipping. Two wheels are in a location closer to the inside. (And it is written on the lid of the flight case.)

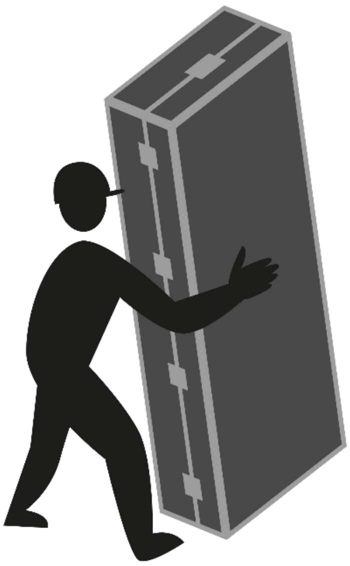


Fig. 3.2-b-Tipping-a-flightcase

Tipping can also be used to get an object **on a higher-level surface**. In this case, you bring the object close to the levelled surface, for example a truck floor or a riser. The object is flipped towards the surface edge and then lifted in such a way that it stays in contact with the surface edge and slides in. This can only be done if the surface is stable. If you tip in this way on a rolling case, there is a risk that the case will move and the object will fall.

The use of tools and equipment to lift, carry and move objects is another way of avoiding. These are discussed in a separate chapter.

Ergonomic methods.

In the chapter below we describe different methods, principals and tips for vertical (lifting and carrying) and horizontal (pulling and pushing) movement. Often a combination of these methods is necessary to move a load in the most ergonomic way.

Keep the load close to your body

The load on your spine does not only depend on the weight of the object you are lifting or carrying, but also on the distance between the gravity point of the object and your spine at waist height.

- Keep the object close to your body. Keep the heaviest side of the object next to your body.
- If a close approach to the load is not possible, try to slide it towards your body before attempting to lift it.

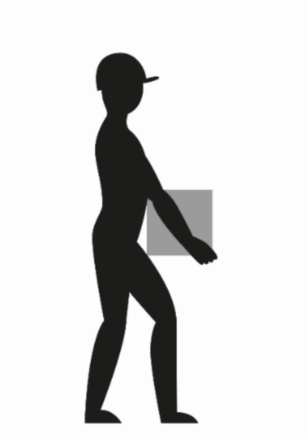


Fig. 3.2-c-close-to-the-body

Balance the load

Using both arms to lift, pull or push ensures a symmetrical load on spine and shoulders. The load will partly compensate, the gravity point stays in the centre and it is easier to keep the spine straight. We do this automatically with heavy loads, but it is equally important with limited weights.

- Divide the load over two arms.
- Use both arms to pull or push.

Stand in a stable way

Ensure you have a stable position before lifting. Keep your feet slightly apart (not wider than your shoulders) with one leg slightly forward to help maintain balance (alongside the load if it is on the ground). Be prepared to move your feet during the lift to maintain a stable posture. Ensure you always keep at least one foot flat on the floor.

Put your feet around the load

When you put your feet around the load, the gravity point of the load will always be inside the support field of your feet. In this way, you will always stand stable.

Fig. 3.2-d-feet

Use your legs

Keep your lower back in its normal curved position and use your legs to lift. At the start of the lift, slight bending of the back, hips and knees is preferable to fully flexing the back (stooping) or fully flexing the hips and knees (squatting). Don’t flex the back any further while lifting. This can happen if the legs begin to straighten before starting to raise the load.

Maintain this curve when lowering the load. You can hurt your back just as easy lowering a load as lifting it. If precise positioning of the

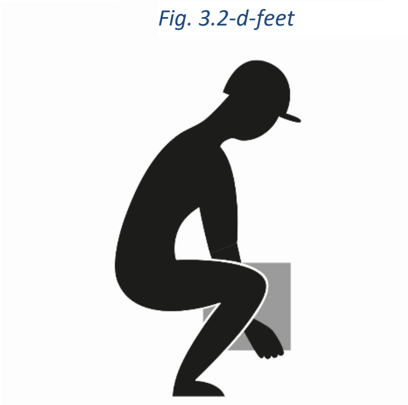


Fig. 3.2--e-use-legs

load is necessary, put it down first, then slide it into the desired position.

When pulling or pushing, the force will always be transmitted to the floor by the legs. Ensure you have optimal grip on the floor and bend your legs slightly to make your body weight do the work.

Use extra support points

Using an extra support point, for example when lifting with one hand, minimizes the impact on the spine. It also increases the support area and makes your posture more stable.

Alternatively, you can also use a support point for the load you are lifting, minimizing the forces on your body.

Fig. 3.2-f-Slide-the-load

Keep your back straight

The natural posture of the back has three curves: hollow in the lower back, sphere between the shoulder blades and hollow in the neck. In this posture, the back can optimally support the load and the intervertebral disks will wear out the least. A back-friendly lifestyle means that you try to keep these natural curves as much as possible throughout the day, also when lifting.

When pushing, the body should be in a straight line from the ankles to the shoulders. The natural posture of the back will then be preserved. The most power can be delivered with hands on shoulder height. For light loads one can push at elbow height and keep the back straight.

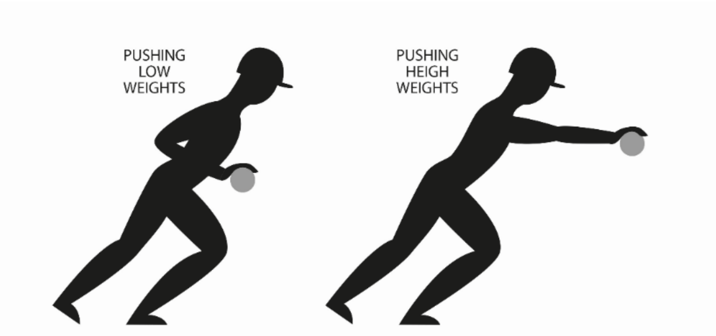


Fig. 3.2-g-straight-back-push

While pulling, it is best to start with the face towards the load while controlling and stabilizing the hollow curvature in the lower back. Once the load is in motion you can turn around.

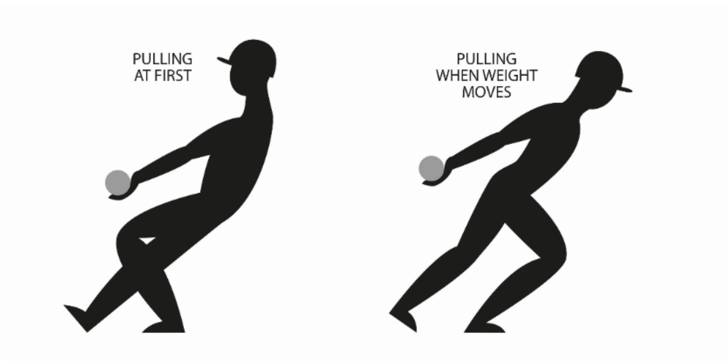


Fig. 3.2-h-straight-back-pull

Keep your head up

Keep the head up when handling. Look ahead, not down at the load, once it is held securely. This improves the right spinal shape

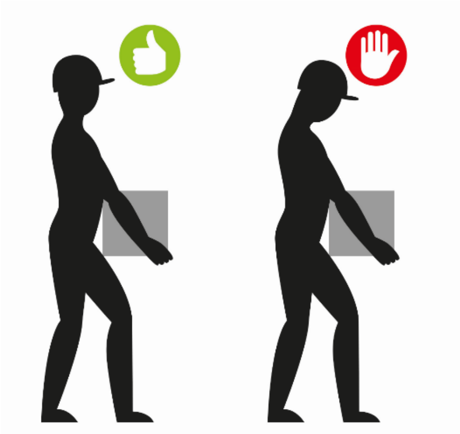


Fig. 3.2-i-head-up

Avoid twisting or torsion

Avoid twisting the back or leaning sideways, especially while the back is bent. Shoulders should be kept level and facing in the same direction as the hips. **Turning by moving the feet** is better than twisting the back and lifting at the same time. To encourage the movement of the feet, the distance between the start and the destination can be increased slightly.

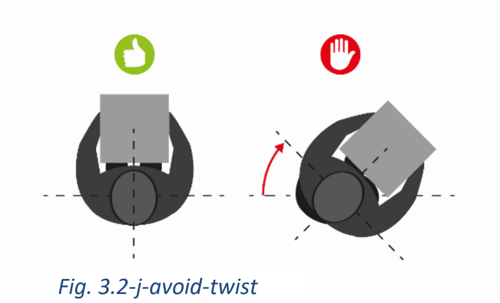


Fig. 3.2-j-avoid-twist

Torsion is also created when pulling or pushing with one hand or when you are not in line with the object to pull or push. Pushing or pulling with both hands improves this situation.

Avoid or limit dynamic force

In general it is good to avoid dynamic forces. Catching a weight of 1 kg that is dropped from 1 m height, can lead to a force on the body of over 15 kg. **Moving along with the direction of the object** when catching and then slowing down lowers the force. This means abrupt starts and stops have a large influence to the risk for your body.

When pulling or pushing a load, **take time to start or stop the load**. Fast acceleration or deceleration multiplies the forces needed. It is better to start slowly and build up the speed over a couple of seconds. Move smoothly. The load should not be jerked or snatched as this can make it harder to keep it under control and can increase the risk of injury.

A second advantage is that with a slow start, you can **use your own weight** to help overcome the inertia of the object. A fast start will mainly use the force from the arms or back, which are stressed unnecessarily. In some cases, it is also useful to push with the whole back to the load.

Of course it is good to make some speed if you want to drive up a slope, here the inertia created by weight and speed will help to limit the force needed to go up.

Ask for help

Don't lift or handle more than can be easily managed. There is a difference between what people can lift and what they can safely lift. If an object is too heavy or unpractical to lift on your own, ask for help. Local rules and risk assessment help identify the limits of what you can lift safely.

When working together, it is extremely important to lift and lower **synchronously**. You both need to lift the load at the same time and put it back on the ground at the same time as well. Otherwise, you will work against each other and one of the persons will carry all the weight. The one that is on the lowest end will get the most weight to carry. That's why it is also recommendable that both colleagues have more or less the same height or use tools like lifting belts that ensure the load is divided equally.

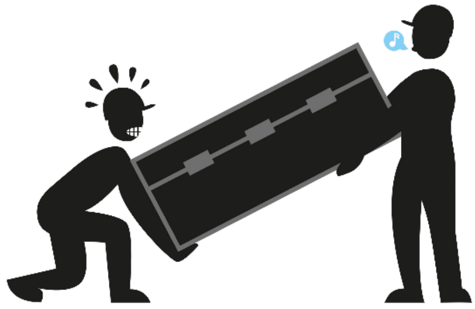


Fig. 3.2-k-Balance

It will be clear that a good **communication** is crucial when lifting together, to ensure the synchronicity of the lift.

When pulling or pushing, the start and stop forces are much higher than the force needed to continue the movement. When moving heavy weights, you can ask a colleague to assist the start and stop.

Pushing is better than pulling

In general pushing is preferable to pulling. The body weight can be used more efficiently and there is less stress on the shoulders. But on the other hand there are some disadvantages to pushing. Your sight of the way you are going is less and stopping is more difficult. For that reason, some tools are developed for pulling, for example a pallet truck.

To spare your back, a good **starting position** is essential. Spreading your legs, with one foot a step forward, gives greater stability to pull or push. If both feet were close together, it would be easy to fall over and you would not be able to use any force.

Specific issues and situations

After the more general guidelines about ergonomic behaviour, we look into some specific issues that occur in the performance and event sector:

One handed lifting

If you lift in front of your body, it is preferable to use both arms, but if you have to lift or pull at your side, it is better to lift with one hand and to avoid torsion of your body using your both hands.

Large, flat vertical loads

Carrying a high set is difficult. Not only do you need to coordinate with your colleague, you also need to keep the set stable and straight up and you need some distance between your body and the set to walk and avoid hurting your legs.

The best way to lift is to stand in front of the side of the set. Ensure that you and your colleague take the set in the same way, the same hand on the same side. Lift with one hand and push the set slightly away from your body by **making a triangle** with your arms and the set. This way, you can walk freely and keep the set in balance.

For longer distances, you can avoid having to walk backwards the whole way, by turning once the set is on the proper height and lift only with one hand.

Manipulating soft goods

Large soft goods like backdrops are heavy, but more importantly they don't have a stiff shape, but are very flexible. When you lift them, their shape changes, they sag and stay partly on the ground. On top of this, it is hard to get good grip. For short distances, it can be better to drag them. For long distances, they should be rolled or folded tight to minimise the negative effects. Where possible, tools should be used to carry or move them.

Lifting from a container

Often, we need to take equipment out of a flight case, a gitter box, … This is difficult because you can't bend your knees, so you need to lift with your back. Try to stand as close as possible to the object you need to lift out of the box and try to lean against the box. This way, you keep the object as close to your body and minimise the stress on your spine. If the objects are not too heavy and easy to grab, you can lift with one hand and use a support point for your other hand. For heavy object you can use tools or ask for help.

Loading counter weights

Loading counter weights for a fly bar system is a difficult action. You need to lift the weight away from your body and you have to pass the anchor rod. Try to avoid torsion when bringing the weights to the anchor. Stand in front of the anchor and bring the weight to the anchor plate with two hands. Let it rest when you change hand and pass the anchor rod. Put the weight in place with both hands. Adapt the anchor height when the stack becomes too high.

Something about pulling vertical ropes

There is not much information available about the impact of pulling vertical ropes, like hemp sets or fly bar control ropes. The impact on the spine seems very limited as you distress rather than stress the spine. But the impact on the shoulder muscles is considerable, especially when pulling a distant rope (like the back rope of a counter weight system).

Pushing and lowering flight cases on a ramp

Ramps are used regularly to load and unload trucks or to bring equipment on temporary stages. A rolling flight case on a ramp is per definition an unstable situation. No extra equipment should be put on top of the case, to avoid sliding during the ride.

It helps to have a certain speed to push a flight case up a ramp. Be sure the way is free and there is space in the truck or the place behind the ramp so you don't need to stop on the slope. Use your body weight and keep your back straight when pushing as explained earlier.

Lowering a flight case from a ramp is mainly breaking its speed, since it would roll off by itself. Be sure the way behind you is free and push against the case, as if you would push it upwards.

What you need to remember

Ergonomic methods describe the way we lift, move, push, pull,… equipment and other loads to avoid the risks of manual handling. Not only the weight and shape of the load influences the risk for damage, but also the frequency of the work.

- Solutions:
- Foresee and prepare.
- Avoid or limit dynamic force.
- Ask for help.
- Apply the ergonomic methods.
- Keep the load close to your body.
- Balance the load.
- Stand in a stable way.
- Put your feet around the load.
- Use your legs.
- Use extra support points.
- Keep your back straight.
- Keep your head up.
- Avoid twisting or torsion.
- Pushing is better than pulling.

Terms and definitions

- ergonomic methods
- tipping
- gravity point
- intervertebral disks
- torsion
- dynamic force
- support point
- personal protection equipment (PPE)
- counter weights
- fly bar system
- ramp

Rehearsal questions

03.02.1 True/False

- Next to weight and shape, also the frequency of lifting or moving something can influence the risk on ergonomical damage.

03.02.2 True/False

- Check your route while unloading the truck.

03.02.3 True/False

- Pulling and pushing can best be done with a straight back.

03.02.4 True/False

- Pulling is better than pushing.

03-02-05 True/False

- Breaking the speed of a flightcase is mainly what you do when unloading a flightcase from a ramp.

3.3 Equipment for lifting, carrying or moving

At the end of this block, you are aware of the proper use of the most common equipment for lifting, carrying and moving.

Equipment for lifting, carrying or moving

There are hundreds of different tools and types of equipment. They all serve a specific purpose. Choosing the right tool is a challenge. But some basic thoughts can help to make the right choice.

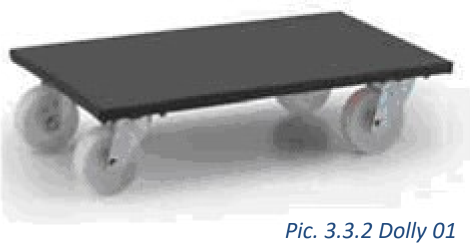
- Most tools are intended to make handling objects easier. But are they also **easy to load**? It doesn't make sense to have a chariot that moves the load easily if loading the chariot damages your back. The best tools avoid loading: the load can be picked up or tipped on the tool.
- Ideally your object is your tool. By **adding wheels** to objects, no manipulation is needed. The object rolls by itself.
- Depending on the surface you are working on, the **size of the wheels** can differ. Large wheels will put the objects higher off the ground, but will start easier. Smaller wheels keep the object closer to the ground.
- When objects have to be carried, **handles** need to be placed in proper places. Ideally, there are enough handles to carry an object with more than one person. The handles are placed so that the object can be lifted in different directions. The handles have a comfortable lifting height.
- **Handle points** of dollies etc. are placed so that they can be moved easily and in a comfortable position.
- Most tools are made for a **specific purpose**, using them in another way can damage the tool, the object, or your back.

Standard equipment and tools

There are a lot of tools and equipment available on the market. These are standardized things for standard situations. In most cases they can also be helpful also in performing arts or event situations.

Dolly

A dolly is a small wooden or plastic board with four wheels under it. Some dollies have two fixed and two castor wheels. They do not always have brakes. We can put boxes or other objects on a dolly and move them around. Larger objects can be tipped back to allow you to put the board with its wheels under the object. After that, the whole combination is tipped back over to land it on the wheels. In this way, no lifting is needed to put the object on the dolly. When loaded, the object is pushed to move the combination. The friction on the surface of the dolly will make it move along. If needed, the dolly can be strapped to the object.



Pic. 3.3.2 Dolly 01

Pic. 3.3.1Dolly 02

Check!

- You have to be careful for high objects. The wheels are rather close together, so the gravity point can move outside the ground surface easily when pushing high on the object, causing the whole to tip. Larger objects can be put on several dollies.
- When the wheels get stuck, the combination can tip or the object can slide off the dolly.

Hand trolley

A hand trolley is a metal plate (tongue) on a frame with two wheels and handles to move your load around. Sometimes these trolleys have 3 wheels on each side to climb stairs. Some of these trolleys can easily be folded to carry and transport them. A hand trolley is used to move heavy, box shaped objects that can be stacked. The tongue is put under the box. Then the trolley is flipped on the wheels till the gravity point is exactly over the wheels. In this way, the only force needed is the force for horizontal movement.

Pic. 3.3.3 Hand Trolley

Check!

- The tongue of the hand trolley can penetrate cardboard boxes.
- Stacked boxes can slide to the side, especially when crossing obstacles like doorsteps.
- When turned upright again, stacked boxes can be unstable.
- All hand trolleys have a maximum load they can carry. Hand trolleys that can be folded can carry less weight.

Platform trolley

A platform trolley is a platform, usually made from wood, in a metal framework with 4 wheels and a handlebar. The handlebar is used to push or pull the trolley around. Most platform trolleys have two fixed and two castor wheels. Brakes are optional. A platform trolley is an easy and stable tool to move more objects of different type and size around. When stacking boxes or objects on the platform of the trolley, you should use the brakes.

Pic. 3.3.4 Platform trolley

Check!

- The disadvantage is that the objects still have to be placed on the floor (which is rather low).
- When crossing a doorstep, or obstacles, the wheels can get stuck and the load can easily slide off.

Table trolley

A table trolley consists of two, usually wooden, platforms in a metal framework with 4 wheels. Most table trolleys have two fixed and two castor wheels. Brakes are usually not available on a table trolley. The table trolley is easy to use for computers, control desks, props, etc. A table trolley has the advantage that objects are moved **on table height**.

Pic. 3.3.5 Table trolley

The trolley needs to be put it in a right position before you load it.

Check!

- The disadvantage for the lower part is that the objects still have to be placed on the floor (which is rather low).
- Bigger boxes do not fit well on the lower level and heavier boxes are hard to lift from there.

Panel trolley

A panel trolley is a metal transportation tool with a small skew, but a long wooden platform and a higher railing with handlebar, specially made to transport **large sheets** in an upright position. The placement of the wheels makes turning with these large sheets easy. A panel trolley usually has two fixed wheels in the middle and two turning wheels at the ends for easy steering. The front and back wheels are placed slightly higher to overcome small bumps. A panel trolley is made specifically for moving large sheets of flat material, scenery flats, long beams, … The floor and the back are angled to ensure the sheets stay in place. When you put it in position, the sheets can be flipped on the trolley and can stick out both ways without limiting the steering of the trolley.

Pic. 3.3.6 Panel Trolley

Check!

- When moving and/or turning, take care of the pieces that are sticking out.
- Can swing out with long pieces.

Pallet truck


Pic. 3.3.7 Pallet truck

A pallet truck is a metal transportation tool with forks that have small wheels and a handlebar for steering that contains a manual pump mechanism and bigger steering wheels. The pump mechanism is used to move the forks higher from the ground. A pallet truck is used to lift **pallets** with a (heavy) load or other materials, prepared for lifting from the ground and to move them around. An example of a standardized version of pallets are euro pallets. They fit in trucks, racks etc. Because of this, they fit in all kind of standardized logistical systems. The forks of the truck are rolled under the pallet. Once in place, the forks can be lifted by pumping the handle of the pump-mechanism and lowered by releasing the pressure. Once the pallet is off the ground, it can be moved around. The advantage of this method is that you only need one set of "wheels" to move a lot of different equipment. The advantage of pallets is that they are designed to be lifted. Another advantage is that pallets have no wheels. Once in place they can't move. Some organizations use pallets instead of different types of dollies and carriages. Sometimes, even sets or set wagons have pallet truck supports to move them.

Check!

- A pallet truck has rather small wheels, which makes it hard to cross obstacles like doorsteps.
- Most pallets can only be lifted in one direction.
- Crossing cables with a heavy load can damage cables.
- There is an ergonomic risk when pulling a pallet truck.

Lifting straps


Pic. 3.3.8 Lifting Straps

Lifting straps are flexible straps, with a loop at both ends, that are used to get a better grip when lifting heavy or hard to handle objects. The straps help to get grip and keep the weight closer to the body. If needed, you can run the straps over the shoulders to get an optimal force division on the body.

Check!

- Be careful to not lift weights that are too heavy, but look as if they can be easier lifted with straps.
- Be sure the straps can't slide of the load, especially when used on a slope.

Specific equipment for theatre

Theatre and event people are creative in adapting their equipment and tools for a more ergonomic use. Below is a list of typical examples, but of course, keeping your eyes open and learning from colleagues will make you find even more of them.

Piano dolly

Pic. 3.3.9 Piano Dolly

A piano dolly is a small chariot with three wheels dividing the weight of a piano leg and making it easier to move the piano. As piano leg wheels can damage the floor, the piano dolly is used to move grand pianos on stage. It is one of the oldest examples of a tool that is still in use. The piano dollies are put **under the small leg wheels** of the piano and ensure it moves smoothly. The wheels fit into the hole in the middle, so the piano can be pushed without falling off the dollies. As the difference in height between the position on wheels and on dollies is small, in most cases the dollies can stay under the piano during use.

If the piano needs to be moved for a larger distance, specific transport dollies exist. Some of them even have caterpillar wheels to climb the stairs. Or the piano is packed in a flight case, with specific openings to be able to mount the legs before unpacking the piano.

Check!

- Avoid rough movement with a piano on dollies, as this distunes the piano.

Control desk tipper

Pic. 3.3.10 Control desk tipper

A control desk tipper or a roller frame is a metal frame with a curved side to turn control desks directly in the right position. A control desk tipper is mostly used for **analogue sound control desks**. The desks are moved on their side and would have to be flipped and lifted on a table to be able to use them. The roller frame is clicked under the desk in its upright position. Then the frame is “rolled” over the curved side.

Check!

- Take care that the tipper is well attached to the flight case.

Counter weight tables

Pic. 3.3.11 Counter weight table

Counter weight tables are heavy-duty tables made of a wooden platform in a heavy-duty steel frame with heavy-duty wheels, especially made for heavy weights. Counter weights used to be stored on the stage floor or the floor of the loading bridges. The loader had to bend to take the weights and twist his spine to move them over to the anchor. Counter weight tables bring the weights at the **same height as the counterweight anchors**. This limits bending of the back while twisting. The table is positioned far enough from the anchor to ensure you move with your feet instead of twisting your spine.

Check!

- Be aware of the ergonomic risk when loading or unloading the table.

Flight cases

A flight case is a solid container, made from wooden panels joined with aluminium profiles. Most flight cases have two fixed wheels and two castor wheels. Sometimes the wheels are equipped with brakes.

The cases are specifically built to protect and transport performance equipment. Sometimes flight cases are custom made, for example for a control desk or a chain host.

Flight cases can be equipped with **wheels** for easy moving and **handles** for easy handling. Ideally, the cases have a low gravity point, to avoid unwanted tipping. Preferably, the cases are made in standardized sizes for easy storing and stacking. A good flight case is a smart combination of a box for protection with the necessary wheels and handles for moving and a smart division or structure on the inside. They minimize lifting and support ergonomic work, because they can easily be moved around during the set up.

Check!

- Check the weight, even if it is written on the case. It is easy to load a flight case full of cables, but it will be too heavy to lift.

Some examples

Flight cases with divisions

Flight cases with divisions are made with wooden plates that can be taken out. This is done to work more efficiently. The fact that every type of cable (or other object) has its own division means that you do not need to unload anything to get what you need. Less handling and lifting limits back overload.

Pic. 3.3.12 Flight cases with divisions

Electrical hoist cases

These cases are organized with a custom made part where the chain hoist fits in perfectly and one where there is space for the chain. The chain is hung and the motor will lift itself out of the flight case. The same happens when lowering the hoist again, the flight case is put under the hoist that will lower itself in the case. In theory there is no manipulation of the motor necessary in normal use.

Check!

- You always need to check if the chain isn't tangled up.

Pic. 3.3.13 Electrical hoist cases

Flight case work station

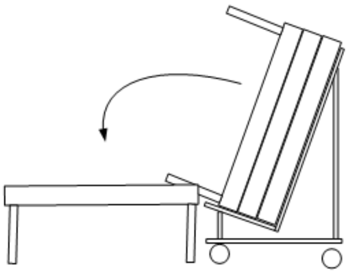
Pic. 3.3.14 Flight case work station

This flight case can be converted into a working station with a table. All tools are organized in separate drawers and the table becomes the lid for transport. The table gives you a comfortable **working position** on the right working height. The tools are organized, so less lifting and manipulating is required.

Cable boxes

This example is more about the use, than the flight case itself. Cable boxes can be put under a truss or fly bar without unloading the cable. When the cables are secured to the fly system, they will unroll themselves when the truss or fly bar goes up. They will roll back in the box when the fly bar comes down. So no manipulation of heavy (multi)cables is needed.

Chariot for risers



Pic. 3.3.15 Chariot for risers

Traditionally, risers are moved flat (horizontal) on trolleys that are the same size as the risers. The disadvantage of this is that every riser has to be lifted to remove it from the dolly. More ergonomic chariots carry the risers vertically in a slight angle. These chariots are made so that the legs can be mounted when the riser is on the chariot. The riser is flipped to put it on his feet, so no lifting or carrying is needed. To load the chariot, the movement is done the opposite way. The riser is flipped on the chariot and then the legs are removed.

Check!

- When lifting the risers, don't pick them up at their legs.

Meat racks

Pic. 3.3.16 Meat racks

Meat racks are metal constructions on wheels, made to store and move spotlights. Meat racks can be used for spotlights with a clamp. Some racks have permanent, but adjustable, pipes to hang the spotlights. Some racks are tailor made for four- or six-bars. Sometimes the floor of the rack can be used to put boxes on with accessories or cables.

The racks can be moved along during setup, so the manipulation of spotlights is minimized. The spot goes from the rack to the suspension system in one move.

Six- and four-bars are prewired bars that hold six or four spotlights. They can be stored as a whole. These bars make manipulation easier and need less wiring. Even if the bars have to be manipulated by two persons, the total stress on the body is reduced.

Check!

- Meat racks are rather narrow and have a high center of gravity, so if loaded wrong, they can easily fall, especially when unloading them from a truck.

Dance carpet wagons

Dance carpet wagons are a metal construction on 4 wheels, specially developed to store and transport heavy rolls of dance carpet. Most of the time, castor wheels are used for these wagons.

Some models also have the functionality to ease the rolling and unrolling of the carpet.

Pic. 3.3.17 Dance Carpet Wagon (Easyroller Showtex)

Check!

- Rolls of dance carpet are heavy and difficult to manipulate.
- The rolls have to be lifted (by definition) from the floor.
- Rolling them properly can include a lot of bending of the back.
- Once rolled, the carpet is sensitive to the pressure of its own weight and should be supported.

Soft goods chariots

A metal frame with a bag made of cloth to store and move soft goods like all kinds of stage cloths. Soft goods chariots make it possible to take down and move soft goods without touching the ground. The fly bars lower the legs directly in the bag. Borders and backdrops are put in without folding. The chariots minimize the handling of unpractical and weighty soft goods, while keeping them in good condition.

Pic. 3.3.18 Soft goods chariot (Canvas hamper Showtex)

Check!

- Try to keep the top side of the legs on top to avoid manual handling.

Ramps

A ramp is a portable slope, made of metal, with edges on either side of the ramp that prevent things from accidentally wheeling off. Ramps are used to bridge gaps or level differences. That way, rolling equipment doesn't need to be carried over obstacles. The surface of a ramp is made to be anti-slip so you have a good foot grip when pushing equipment on the ramp. Some ramps hook on a truck or loading platform. The slope of a ramp is expressed in % (cm / meter) and is mostly limited to 30% (30 cm per meter).

Pic. 3.3.19 Ramp

Check!

- Always check whether the ramp is positioned well and cannot slip away.

Permanent installations

Tools to improve the ergonomics do not only occur in temporary, movable appliances. They can also be permanently installed in a **building**. Some examples are:

- A rail with a chain hoist above the audience area to move heavy mixing desks in the front of house mixing position.
- A hoist to bring spotlights up the lighting bridges.
- Loading docks with changeable heights and docking shelters

Nice to know

.

Pic. 3.3.20 Different types of scenery hooks, Ivo Kersmaekers

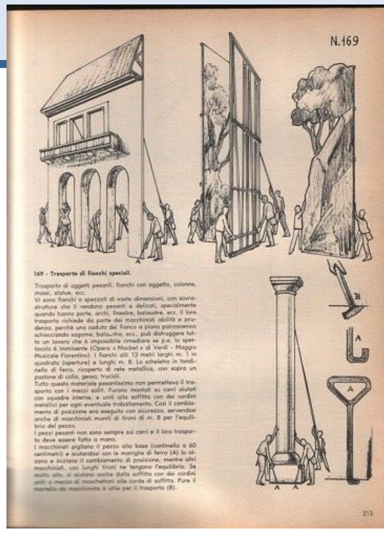
Transport handles and scenery hooks

The issue of lifting is not new. Tools have been developed over centuries to lift and manipulate sets in an ergonomic way. These tools have one goal in common, providing a good grip on a comfortable height.

The long hooks provide a fixed lifting height, while providing grip. These can be used to lift upstanding sets, possibly in combination with braces to guarantee stability.

The short hooks, also called "iron hands" can be used to move sheets, where it is not desirable to have handles. The forks provide a good grip and their shape makes them grab the wood. You can put them at any height, so they adapt to different persons.

Pic. 3.3.21 Boar



N.169

169 - Trasporto di fianchi speciali.

Trasporto di oggetti pesanti. Fianchi con aggetto, colonne, massi, statue, ecc.
Vi sono fianchi o spezzati di vaste dimensioni, con sovrastrutture che li rendono pesanti e delicati, specialmente quando hanno porte, archi, finestre, balaustre, ecc. Il loro trasporto richiede da parte dei macchinisti abilità e prudenza, perchè una caduta del fianco a piano palcoscenico schiacciando sagome, balaustre, ecc., può distruggere tutto un lavoro che è impossibile rimediare se p.e. lo spettacolo è imminente (Opera « Macbet » di Verdi - Maggio Musicale Fiorentino). I fianchi alti 13 metri larghi m. 1 in quadrato (aperture) e lunghi m. 8. Lo scheletro in tondinello di ferro, ricoperto di rete metallica, con sopra un pastone di colla, gesso, trucioli.
Tutto questo materiale pesantissimo non permetteva il trasporto con i mezzi soliti. Furono montati su carri aiutati con squadre interne, e uniti alla soffitta con dei cordini metallici per ogni eventuale traballamento. Così il cambiamento di posizione era eseguito con sicurezza, servendosi anche di macchinisti muniti di tironi di m. 8 per l'equilibrio del pezzo.
I pezzi pesanti non sono sempre sui carri e il loro trasporto deve essere fatto a mano.
I macchinisti pigliano il pezzo alla base (cantinella a 60 centimetri) e aiutandosi con le maniglie di ferro (A) lo alzano e iniziano il cambiamento di posizione, mentre altri macchinisti, con lunghi tironi ne tengono l'equilibrio. Se molto alto, si aiutano anche dalla soffitta con dei cordini uniti a mezzo di moschettoni alle corde di soffitta. Pure il martello da macchinista è utile per il trasporto (B).

213

Pic. 3.3.22 scenery hooks, Trattato di Scenotecnica by Bruno Mello in 1960

What you need to remember

- Choosing the right tool for lifting, carrying or moving is a challenge. Remember:
- Avoid loading if possible.
- Adding wheels makes your object easy to manipulate.
- The size of the wheels does matter, this depends of the surface.
- When carrying, handles must be properly placed to move in an easy and comfortable way.
- When carrying, there must be enough handles.
- Using a tool in a wrong way can cause damage to you, the object or the tool.
- The most common equipment for lifting carrying and moving:
  - Dolly
  - Hand trolley
  - Platform trolley
  - Panel trolley
  - Pallet truck
  - Flight case
  - Meat rack

Terms and definitions

- dolly
- hand trolley
- platform trolley
- panel trolley
- pallet truck
- flight case
- meat rack
- ramp
- handle
- tongue
- maximum load
- pallet
- lifting strap
- piano dolly
- control desk tipper
- riser
- dance carpet
- soft goods

Rehearsal questions

03.03.01: The best way to move a flat scenery element is a

a) Trolley
b) Panel trolley
c) Pallet truck

03.03.02: True/False

- Lifting straps are used to lift heavy weights on a crane.

03.03.03: True/False

- A motor hoist flight case can lift itself in a truck.

03.03.04: Meat racks are used to move

a) spotlights
b) sound equipment
c) dance carpet

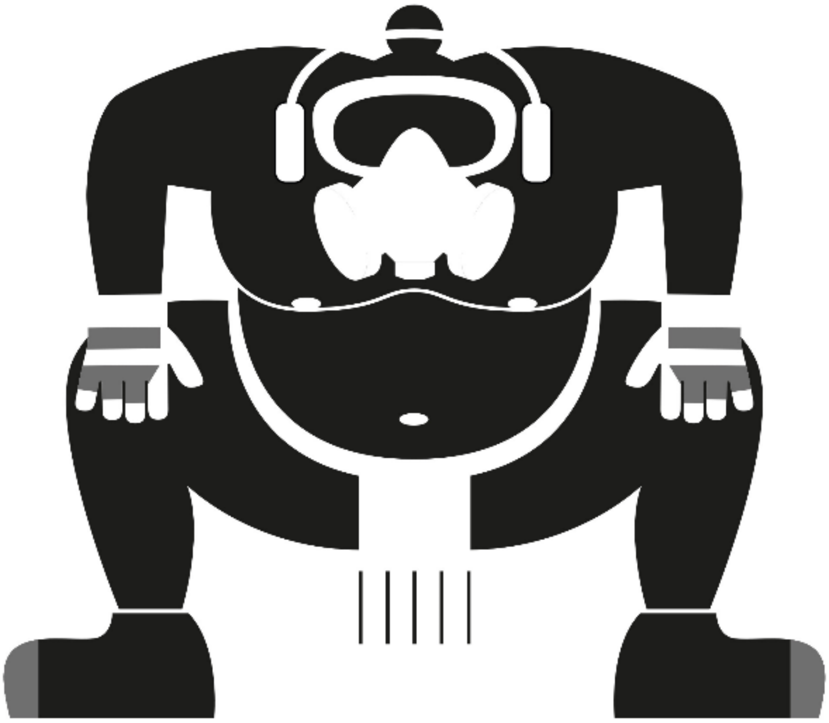
03.03.05: Soft goods chariots are used to move

a) cables
b) drapes and curtains
c) goody bags

03.03.06: The safe angle to work with a ramp is

a) 45%
b) 30°
c) 30cm/m

4 Use personal protection equipment



TO USE PERSONAL PROTECTION EQUIPMENT, YOU MUST:

Assess the need for personal protection equipment (PPEs) according to training, instruction and manuals. Inspect the equipment and use it consistently.

This means you master following skills:

- Identifies / spots the risks for personal injury
- Chooses the appropriate PPEs according to the risks
- Checks the PPEs before use
- Uses safety shoes, hearing protection, gloves, hard hats etc. according to instructions and regulations
- Chooses a safe attachment point for the fall protection
- Maintains and stores the PPEs

You master following knowledge:

- Body protection
- Eye and face protection
- Hearing protection
- Breathing protection
- Fall protection
- Mandatory action signs

You have following attitudes:

- Personal safety awareness
- Awareness of long term impact on personal health
- Non macho attitude

Introduction

Statistics show that a lot of **injuries** could have been prevented with the use of the right personal protection. These accidents would not have caused personal suffering, work absence, financial loss, etc. if Personal Protective Equipment (PPE) had been used.

Personal Protective Equipment (PPE) is equipment used by the individual to **reduce the effects** of an accident. This equipment does **NOT prevent accidents**, but reduces the effect of accidents on the human body. PPEs do NOT guarantee permanent or total protection for the wearer. PPEs are **the last line of protection** against hazards, after we have taken structural or collective measures to prevent accidents. When we can't fully eliminate or control the hazard, then we use PPEs.

The importance of the use of PPEs is supported by EU "Framework Directive" (89/391/EEC) that states the use of PPEs as one of the **duties** of an employee. It literally states: "[the employees] make correct use of the personal protective equipment supplied to them and, after use, return it to its proper place "

Identify risks

The first thing you need to do is to identify the risk of an activity you are going to undertake. You have to look for the risk of splinters, bruises, falling things, dust, (hot) particles darting away, extreme noise, splashing chemicals,… You can also take into account the environment you will be working in. Will it be cold, hot, wet,… In conclusion, you look for things that can hurt your body, and especially your head, your hands and feet, and eyes and ears.

In some situations or sectors, there are PPEs you always use, even though you did not spot any direct risks. But you know the risk of something occurring is high, because of the **high-risk area** you will work in. This is why, when you go to work on a stage, you automatically have to wear your safety shoes. And when someone is working above you/on height, you wear a hard hat.

Choose proper equipment

Even when the PPEs are supposed to be provided by your employer, you have to check if they are right for the job you are going to do. A **PPE will only work properly if it fits**. If it does not fit properly, it will not improve the safety or even cause new risks. So take your time to check if it suits the job and fits your body.

Fig. 3.3.a Choosing-the-right-protection

Use equipment

Simply having Personal Protective Equipment available is not enough. You have to **use it**. No one else can protect you with PPEs, using them is your responsibility. Be sure to know how and when to use them. If you are in doubt, read the manual or ask for help. Do not allow yourself to not use them for jobs that 'only take a few minutes' or to find other **excuses**.

Some equipment will need some adjustment to fit perfectly and to protect you in the best possible way.

These actions should become part of normal work practice:

- If you are going to work on or around a **stage**, always wear safety shoes.
- If there is a **sound check**, wear earplugs.
- If someone is working on **height**, wear a hardhat.
- If you are **unloading** a truck of trusses, wear gloves, safety shoes and earplugs.

This should become an automatism, just like you would use a flashlight in the dark.

Check equipment

Always check your equipment before using it. What you need to check depends on the type of equipment. But in general, you look for damage, wear and tear, missing parts and test the functionality. The first time you use new equipment, this will take a bit longer and you should also check the instructions, labels etc. But once you are used to it, checking it will take only a second.

If you see **damage or malfunctions**, report this to the safety responsible. When you think improvements in comfort or quality could be made, provide feedback to the safety responsible as well. This way, they can take your comments into account when buying new equipment.

Some equipment needs regular **specialist checks**. The expiration date of the check will be marked on the equipment. Some other equipment will have a limited life span, which will also be marked. If it is not checked or replaced in time, warn the safety responsible.

Fig. 3.3.b Check PPE

Maintain equipment

After use, the equipment needs to be **checked, cleaned and stored** properly. Clean the equipment when needed. If specific treatment is needed, the manufacturers' guidelines will give directions. Dirty equipment can cause new hazards. Store the equipment according to the manufacturers' guidelines. This ensures no damage can occur during storage or transport. Missing parts should be reported, in order to be ready for the next job. Some PPEs have a limited life span. This should be checked on a regular base.

Do not **repair** PPEs yourself. This has to be done by a specialized person and checked for its safety functions afterwards.

Terms and definitions

- Personal Protective Equipment
- collective measures
- identify risks
- wear and tear
- expiration date

4.1 Body protection

At the end of this block, you know the standard personal body protection equipment.

Body protection (foot, hand, arm, leg, head,...) will protect you against all kinds of external influences. Safety shoes will reduce the impact of dropping heavy objects on your **toes** or stepping on nails from below. Gloves will reduce the impact of getting your **hands** clamped between cases and stop splinters or rough objects from hurting your skin. A hard hat will reduce the impact of falling objects or bumping your **head**. Working clothes will protect you against cold, heat, burn injuries, or chemicals.

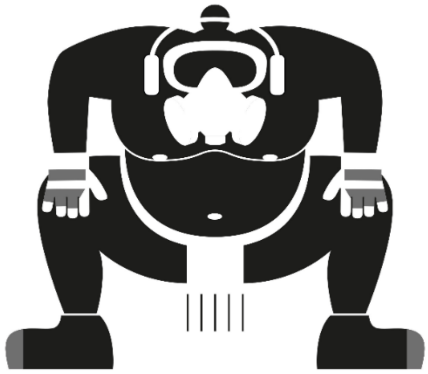


Fig. 4.1.a Body-protection

There is a large variety of risks that can be reduced by body protection. Every one of these risks will demand specific properties of the personal protection equipment. This means the variety of shoes, gloves, hard hats and clothes is huge and choosing the right type (of equipment) is the first step to safety.

Different types, their properties and their use

Safety shoes

Pic. 4.1.1 Safety shoe

Safety shoes come in a variety of styles and properties, meeting the needs for different uses and risks. The most important properties are:

- **Steel toe caps**. These protect the toes of the wearer against impact of falling or rolling objects.
- **Anti-perforation soles** protect against perforation of the shoe from below, for example when stepping on a nail.
- **Antiskid soles** give you a good grip on the floor and avoid slipping and tripping.
- **Shock absorption** heels minimize the influence of shocks on the body and especially on the spine.
- The height of the shoe: a higher shoe will protect the ankle, but low shoes give more **comfort** when you need to bend or sit on your knees.
- **Ventilation** of the foot in the shoe is especially important when shoes are worn for long hours.
- The **resistance** of the material can include water tightness, weather resistance and resistance against chemicals.
- The **thermal quality** can protect against cold or heat.
- **Electrical isolation** protects from ground potential.

On top of these general properties, shoes need to be **adapted to the situation** you are working in. For example, in a performance situation, you want to be able to walk silently.

Safety shoes have to be worn in all situations where there is a hazard for the feet. In a performance environment, we think of workshops, during the loading and building of sets, changeovers, etc.

Safety gloves

Gloves also come in a wide variety, but for performance use they mainly protect against splinters, abrasions and bruises from working with rough materials, and small burns from hot surfaces like spotlights.

Pic. 4.1.2 Safety glove

Specific gloves exist for welding, working with electricity (risks of electric shock and/or arc flash), or manipulating chemicals.

Next to the mechanical properties of the glove, the most important property is that they **fit** well and are **flexible** enough to use your fingers with enough detail to manipulate small bolts, screws, etc.

Working clothes

Working clothes are the most underestimated part of body protection. In the first place these clothes have to provide you with the necessary comfort to work, but they should also be made so that they protect you at the same time. Some points to pay attention to:

- Working clothes should be made so that you **don't get stuck or hooked** behind sets or cases.
- Working clothes should have **closable pockets** to avoid things falling out when you are working on a grid or at heights.
- Working clothes should have a minimum of **fire retarding** properties, especially when you are working in a workshop, with special effects, or when larger arc flash risks exist.
- Working clothes should provide **protection** against rain, cold and heat if you are working outside.
- Working clothes should make you **visible** in situations when needed (like traffic, open air set-ups, etc.).

Pic. 4.1.3 Safety coat

For specific activities like welding or working with chemicals, specialized clothing should be worn.

Hard hat

Our heads need to be protected against **falling objects**, bumps and so on. Head injuries can result in permanent damage or even death. This means, when there is a risk for falling objects, tools, bolts etc. you should wear a hard hat. Concrete situations are when someone is working above you on scaffolding, a ladder, a lifting device, in trusses or on the gird.

Pic. 4.1.4 Hard hat

When there is a risk for **bumping** your head, while climbing or working in spaces with a lot of beams you should protect yourself too. This also includes situations where you could **fall** and use fall protection. It would be a pity if your fall arrest saves your life, but you still get injured by bumping your head. Hard hats come in different sizes and with different properties. Most important properties are:

- **Mechanical, thermal and electrical resistance**. The outer cap must resist the shock of a falling object. It also must resist penetration of sharp objects.
- Adaptability and quality of the **inner suspension straps**. The headband has to be adjustable to ensure it fits your head perfectly. The inner suspension is very important, as it spreads the impact on the helmet over the top of head.
- Adaptable and comfortable **chinstrap**. The chinstrap keeps your hard hat on your head in every position.
- The front **brim** protects your face, but on the other hand, the brim limits your view. When you have to look up regularly, which is often the case in a performance environment, a small brim is more convenient.
- Compatibility with **accessories**. When you are wearing a helmet, you should be able to combine this with a headlamp, ear protection or eye protection. Ideally, they fit directly in slots on the hard hat.
- In some organizations, the **colour** of the hard hat will reflect your function or responsibility.

Inspection method for PPE

The **first time inspection** needs to include the conformity and the necessary labels.

There should be **daily inspection** checks to see if the equipment is clean, if there are no marks of wear and tear, and if there are no missing parts, locks, straps, etc. We don't want any "temporary repairs". Shoes or hard hats repaired with gaffer tape do not guarantee any safety. For this reason, we do not want stickers on the equipment as they can mask damage.

Regular inspection will check the expiring date and conformity labels.

Maintenance

This type of PPE is mainly worn on the body. So it has to be **washed and cleaned** on a regular basis. Check the maintenance guidelines of the manufacturer to be sure the washing does not affect the integrity of the PPE.

What you need to remember

A large variety of risks can be reduced by body protection. Different types of body protection used on or around stage are:

- Safety shoes
- Safety gloves
- Working clothes
- Hard hat

Daily inspection of body protection is required to check for wear and tear. Regular inspection is required to check

Terms and definitions

- body protection
- safety shoes
- safety gloves
- working clothes
- hard hat
- daily inspection
- regular inspection

Rehearsal questions

04.01.01: True/false

- Wearing a hard hat is only necessary when colleagues are working above you.

04.01.02: Standard working gloves will protect you against:

a) electric shock
b) splinters, abrasions and bruises
c) arc flash
d) corrosive chemicals

04.01.03: Working clothes have closable pockets to avoid

a) you standing with your hands in your pockets.
b) you taking bolts and nuts home.
c) things falling out.

04.01.04: True/False

- With a hard hat, you can work safely under a load.

04.01.05: PPEs have to be inspected

a) Daily / every time you use them
b) Weekly
c) Monthly
d) On the expiring date

4.2 Eye and face protection

At the end of this block, you know the standard eye and face protection.

Working in theatre or events will often include **sawing, sanding, drilling** and other activities that can damage your eyes. Safety glasses, goggles and face screens will protect you against **dust, particles** darting in your eyes or face, eye or skin irritation by dust or **chemicals**, etc. Welding glasses or screens will protect you against the **blinding effects** (welding eye).

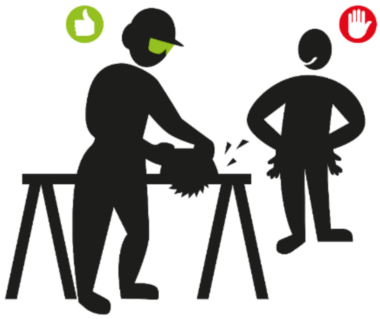


Fig. 4.2.a Goggles

Different types, their properties and their use

Safety glasses

Safety glasses are used to work on stage, where there is no specific risk for the eye, but a risk of **damaging your glasses**. People who need to wear glasses anyway to improve their sight can use safety glasses at their workplace, when there is a risk of damaging ordinary glasses. The safety glasses are like normal glasses, adapted to the wearer's eyes, but they are break and scratch resistant.

Pic. 4.2.1 Safety glasses

Safety goggles

Safety goggles protect the eyes **against dust, splinters, small projectiles, sparks** from grinders, etc. They are made of break and scratch free material and connect well to the skin, so no particles can enter from the sides. It is important that they don't reduce the viewing angle or reduce the viewing quality.

Pic. 4.2.2 Safety goggles

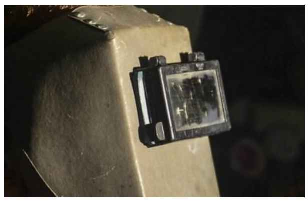
Face screens

Face screens mainly protect against **small projectiles or particles** that can hurt or irritate the skin of the face. Face screens are worn on a headband or in combination with a hard hat. Specific safety screens exist to protect against electrical risks, mainly the risk of an arc-flash (heat radiation and metal particles).

Pic. 4.2.3 Face screen

Welding glasses

Welding glasses reduce the **intense light** that originates from welding. They can be used separately or in combination with a protective screen.



Pic. 4.2.4 Welding glasses

General properties

In general, eye protection needs to comply to the following criteria:

- High **break resistance** of the optical material
- **Scratch proof** optical material
- Good **optical quality** adapted to the work
- Does **not limit the view** of the user
- **Solid** construction
- **Connects to the face** to avoid products or particles entering the eye
- **Resistant** to the products or situations used
- High wearing **comfort**

Inspection method

During a **first time inspection**, check labels and instructions, check for initial damage, adapt to your personal size to improve wearing quality and safety.

A **daily check** should include checking for scratches or cracks and wear and tear.

Regular inspection should also include checking the expiration date.

Maintenance

- Clean according to manufacturer's instructions.
- When not in use, store in a proper casing.

What you need to remember

Different types of eye and face protection used on and around stage:

- Safety glasses
- Safety goggles
- Face screens
- Welding glasses

The quality is important, demands are: solid, high break resistance, scratch resistant, good optical quality and not limiting the wearer, has to fit well and provide good comfort.

Terms and definitions

- safety glasses
- safety goggles
- face screens
- welding glasses

Rehearsal questions

04.02.01: If you need glasses to see properly, you can best

a) Wear safety goggles all day.
b) Wear safety glasses.
c) Not work on stage.
d) Wear a face screen when at work.

04.02.02: If there is a risk for an arc flash, the best thing to protect you is

a) Safety glasses
b) Welding glasses
c) A face screen

4.3 Hearing protection

At the end of this block, you:

- Understand the risks of noise and sound.
- Know the different types of hearing protection.
- Know when to use hearing protection.

Hearing loss

Sound is inherent on our work environment. We produce loud sounds as part of creating performances and events. Hearing loss has not been seen as a major problem for years. The fact that losing your hearing is a slow process, without dramatic consequences such as bleeding, deformity, or death and the fact that hearing protection seemed incompatible with our work created a lack of motivation to protect us from it.

"Blindness cuts people off from things; deafness cuts people off from people." (Helen Keller)

Hearing loss is **irreversible** and makes it difficult to function in a performance environment. On top of this, sound operators with hearing problems will compensate in their mix and create extra risks for the audience and colleagues. Hearing loss also influences your social life and the enjoyment of music.

Hearing loss is caused by a combination of the **level** of sound and **how long** you have been exposed to it. Hearing damage is caused by loud noises as well as by exposure to more moderate noises during longer periods of time.

There are 3 main types of hearing problems:

- General reduction of **level** of sound perception
- Reduction of the perception of **specific frequencies** in your hearing spectrum
- **Tinnitus**, a permanent, constant "beep" in your ears

Risks in theatre and events

The risk for hearing loss in performing arts and event activities is most present in four situations:

- Working in **workshops**, with machines etc.
- Working with **trussing and steel**
- **Performance** sound
    - Reinforced sound, especially during sound checks where the risk for feedback loops is the biggest

- Not reinforced sound, especially in the orchestra pit
- Long exposure to high sound levels

- **Pyrotechnics, weapons and special effects**

Some of these factors also cause a risk for the audience. But you can (partly) protect the audience by increasing distances, adapting acoustics, limiting sound levels and limiting exposure time. This means the protection measures for an audience are (in general) not enough for the stage workers.

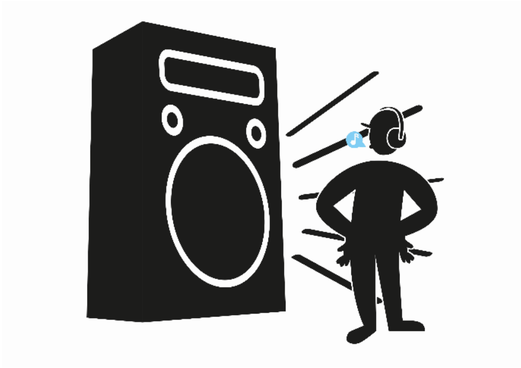


Fig. 4.3.a Noise

Protection measures

Personal protection is done by limiting the sound that can enter the ear. The most important factor to choose a type of protection is noise reduction. Factors that can influence the choice are:

- What is the **sound reduction** needed?
- How important is **communication** during the wearing?
- Does the wearer **need to hear** a balanced frequency spectrum?
- Can it be **combined** with other PPEs?
- Is it **comfortable** for the duration of time it needs to be used?
- How **frequent** is the protection is used?

Based on the answers to these questions, a specific type of protection can be chosen:

Hearing protection comes in two groups:

In your ear: earplugs

Earplugs exist in disposable or reusable versions. They are **inserted in the ear canal** to block sound. They should be inserted in a proper way to seal off the ear canal tightly.

Pic. 4.3.1 ear plugs

For a higher quality and more comfortable use, plugs can be moulded to the individual ear.

For activities where communication and exact sound reproduction are important, plugs can have filters that are frequency neutral or where the voice frequencies are given an advantage. Some plugs can be equipped with extras like small speakers, so they can also be used as monitoring devices. This makes them compatible with sound engineering work.

Pic. 4.3.2 moulded ear plugs

Earplugs are discrete and can be used with other protection equipment

On your ear: headsets

Protection headsets are used to protect against exposure to noise by blocking the sound **outside the ear**. The earmuffs are made from sound-attenuating material and soft ear cushions that fit around the ear and hard outer cups. They are held together by a headband. They are designed so that one size fits most head sizes. The effectiveness of hearing protection is reduced greatly if the hearing protectors do not fit properly. The headsets should tightly seal against the side of the head. Hair and clothing should not be in the way.

Pic. 4.3.3 sound reduction headset

Specific types can be **combined** with a hard hat or even used as a monitor or communication headset. Normal radio or intercom headsets, even if they look the same, are not substitutes for hearing protectors!

When?

Hearing protection should always be worn if the sound level is (or can accidently become) **too high, too long** or if you feel **uncomfortable** with the sound level. The effectiveness of hearing protection is reduced if it is worn only a part of the time during periods of noise exposure.

What you need to remember

- Hearing loss is irreversible and caused by a combination of the level of sound and how long you have been exposed to it.
- In theatres there are several risks that can cause hearing loss. Personal protection is done by limiting the sound that can enter the ear.

Terms and definitions

- hearing protection
- hearing loss
- tinnitus
- trussing and steel
- sound checks
- feedback loop
- reinforced sound
- pyrotechnics
- weapons
- special effects
- acoustics
- sound reduction
- earplugs
- headsets
- frequency neutral

Rehearsal questions

04.03.01: What are the 4 most important causes of hearing loss in a performance or event environment? (Open answer)

04.03.02: When do I need to use hearing protection? (multiple answers)

a) Always
b) When weapons are used on stage
c) When carrying truss
d) When carrying soft goods

04.03.03: True/false

- I can use my home headset for hearing protection.

4.4 Breathing protection

At the end of this block, you:

- Know the different types of breathing protection used in performance and events.
- Know how to check and clean the breathing protection.

Within our work, there is always a risk that dust or chemical substances are released into the air. Breathing in these substances can be annoying, make it hard to breath but it can also cause damage to your lungs. The substances can be toxic or even carcinogenic.

Breathing protection in the performance and entertainment sector is in most cases limited to the protection against environmental contaminants. The equipment will only filter the contaminants out of the environment air, but will not supply fresh air. This means that the environment air still needs to contain a sufficient amount of **oxygen** (at least 17%) and the space needs to be well **ventilated**.

In industrial environments, sometimes **isolating respirators** will be used that provide the user with external air through airlines or air cylinders. These require highly specialized personnel and are not described here.

Breathing protection does not replace **collective protection** like air extraction systems or dust collection systems. Air extraction systems extract and filter air from contaminated rooms like paint booths. For smaller, partial areas like soldering tables or brush cleaning sinks suction hoods are used that extract and filter the air from a specific spot. Dust collection systems will collect dust at the source, like a sawing or freezing machine for woodwork.

Risks in theatre and events

The most typical risks in a performance or event situation are:

- **Dust** from woodwork
- Fumes from **spray painting**
- Fumes from **soldering**
- Fumes from **chemicals** while
  - Applying Polyester
  - Cleaning with toxic products

The need for breathing protection will become clear from a **risk assessment** of the concrete work situation. The person responsible for safety will decide what measures to take. It is up to you to follow his/her instructions.

Prevention measures

Breathing protection that protects against environmental contaminants occurs in 3 types, disposable mouth masks, half masks and full face masks:

Disposable mouth masks

These are the most simple versions of breathing protection and they protect against solid particles, water based aerosols and non-ethereal aerosols. There are 3 classes:

- P1 (hindering) protects only against **solid particles**
- P2 (harmful) protects against **solid particles and fumes (water based aerosols)**
- P3 (poison) protects against **solid particles and fumes (non-ethereal aerosols)**

The mask has to fit tight to the face and the nosepiece needs to be adapted. To check if the mask fits, close the mask off with both hands and breath out. If there is air passing along the nosepiece, it needs to be adapted more.

Pic. 4.4.1 Disposable mouth mask

The mask needs to be disposed and replaced:

- When breathing **resistance increases**.
- When **damaged**.
- At the **end of a job**.

Half masks and full face masks

Half masks and full face mask provide a better protection and are used with exchangeable filters for different types of hazards. The type of filter required has to be defined by an expert. There are filters for dust and for different types of chemicals. The filters for chemicals are colour-coded.

Pic. 4.4.2 Half mask

Some important instructions when using the masks:

- Put the mask on **before you enter** a contaminated room.
- **Check** if the mask fits by closing the exhalation valve with your hand and breathing out, the mask should bulge. (Positive pressure test)
- **Check** if the mask fits by closing the filters valve with your hands and breathing in, the mask should collapse. (Negative pressure test)

Pic. 4.4.3 Full face mask

- Leave the room:
  - In case of **dizziness, difficult breathing, extreme tiredness, vision problems** or other health issues.
  - If the **breathing resistance** becomes too high.
  - If you **smell or taste** contamination.

You have to take great care with **beards and moustaches!** They can compromise the air tightness of the mask.

Maintenance

The masks need to be cleaned and checked after every use.

- **Disinfect** the mask if needed.
- **Clean** the mask by submerging it in lukewarm water (50°).
- **Brush** the mask clean.
- **Rinse** the mask.
- **Inspect and replace** damaged parts.
- **Replace** the mask if it is broken or if the breathing resistance becomes too high.

The mask and filters should be kept in an airtight container to avoid contamination.

What you need to remember

Breathing protection in the performance and entertainment sector is in most cases limited to the protection against environmental contaminants.

- This means that the environment air still needs to contain a sufficient amount of oxygen and the space needs to be well ventilated.

Breathing protection can protect against

- Solid particles
- Fumes (aerosols)

There are 3 types

- Disposable mouth masks
- Half masks
- Full face masks

Terms and definitions

- breathing protection
- chemical substances
- contaminants
- oxygen
- ventilation
- fume
- toxic
- solid particle
- aerosol
- dizziness

Rehearsal questions

04.04.01: True/False

- A Disposable mouth mask protects you against a lack of oxygen.

04.04.02: If you wear a full face mask and you feel dizzy, you should

a) Remove the mask.
b) Leave the room.
c) Remove the filter.

4.5 Fall protection

At the end of this block, you know the different types of equipment for fall protection and their use.

Before we go in detail about the different types of equipment for fall protection and their uses, we need to clarify some different uses of equipment that are often confused.

Collective protection

Collective protection is not a type of personal protection equipment, but just as a reminder we include it here. The best way to protect people against falling is still a collective solution that **protects everyone**. Railings or a guardrail system will prevent anyone from falling to lower levels.

Fall restraint system

Fall restraint is a technique whereby personal protective equipment **prevents a person from reaching zones** where he risks falling from a height. A restraint system allows a worker to perform their task without the possibility of losing contact with the walking/working surface. The fall restraint system makes it impossible for a person to fall, by connecting the person to an anchor point with a lanyard that is too short to reach the point where he/she could fall. The anchor point will not be subjected to an impact load.

Fall arrest

Fall arrest systems arrest the fall of the worker by dynamically **absorbing the energy of the falling worker** before he collides with the ground or other objects. In other words, the worker is still at risk of falling, but when he/she falls, the fall is stopped **before reaching the ground**. The shock of stopping is absorbed to avoid injuries. A typical system would contain a body harness, a lanyard with a shock absorber, connectors and an anchorage. The anchor point is subject to shock loads, so it has to be chosen (and tested) carefully.

If you use a fall arrest system, you have to be sure you can be rescued when you fall. A **rescue procedure**, trained people and rescue equipment must be available on the spot before you use the fall arrest. It would be absurd to first be saved by the fall arrest, but then get injured because you can't get rescued in a proper way.

Work positioning

Work positioning is a technique to position yourself so that you can **work ergonomically**. This is done in situations where you would need your hands to stay safely in place and you want your hands free to be able to work. You are supported in tension or suspension in such a way that a fall from a height is prevented or restricted.

Rope access

Rope access, sometimes also referred to as suspension, is a **method to get access to structures by using ropes**, climbing and aid climbing techniques with fall protection. Rope access is a very specialised activity and will not be discussed here further.

When do you need to use fall protection?

The simple answer to this question would be, "fall protection needs to be used whenever there is a risk of falling from heights or into depths present". But in reality, **deciding** the need to use fall protection is the result of a complex process. The option of using fall protection can only be taken after a risk assessment.

Within the risk assessment process, the first step will be to **eliminate the risks in a collective manner**. If it is possible to adapt the workplace by putting barriers, for example, this is preferable. The barriers will eliminate the risk for everyone.

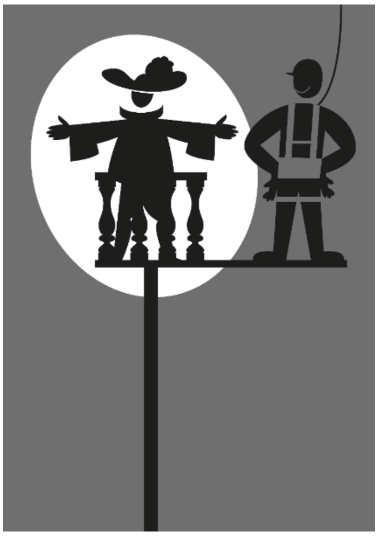


Fig. 4.5.a Fall-protection

The next step is to see if a **travel restraint** is possible. This is an individual measure, but still eliminates the risk of falling. Therefore it is preferable to a fall arrest. In specific cases a combination of barriers and travel restraints can be necessary. For example if you need to reach over the railing to reach spotlights.

If collective measures and fall restraints are not possible, the **different hazards have to be evaluated**. These include the height of a possible fall, the availability of anchor points, the risk of swinging when falling, the surface you can fall on, and the circumstances you work in (weather, debris,….). This evaluation will not only tell you whether or not you have to use a fall arrest, but also how you have to use it.

Training

Fall arrest systems seem simpler than they are. To function properly when things go wrong and to minimise secondary injuries from a fall, all details must be looked at. You need to be trained to use the system on a regular base. Minimum training has to contain:

- **Adapting** the harness to your body.
- **Choosing** the proper attachment points on the harness.
- **Recognising** the proper anchor points.
- **Securing** yourself when moving and working on heights.
- **Maintenance** of your equipment.
- What to do in case you **fall**.

If you are not trained, you are a risk for yourself and your colleagues when working on heights.

When things go wrong

An old saying states that falling is not all that bad, it is hitting the ground that hurts. If things go wrong, and you fall from a height, there are several things that can happen and there are several hazards that occur.

Falling

If you would fall without any protection, you would impact the surface with a speed that is related to the height you fall from. To give an idea of this impact, a person of 60 kg that falls 3m deep will hit the surface with a speed of 27 km/h and an impact of 15.000 Newton (1500 kg).

This principle doesn't change when you use fall protection. The difference is that you are stopped before you hit the surface. The length of your fall will now define the **impact of your harness** on your body. This is why it is important to keep lifelines short. To reduce the shock, we use shock absorbers. But there are several other hazards that can influence your fall:

The first thing that could happen is that you would **hit objects** sticking out into the path of your fall. This can cause extra injuries.

Secondly, you could **swing against an object** when falling. This will happen if your anchor point is not in line with the direction of your fall.

A third possible hazard occurs if you are unconscious. This unconsciousness can be the cause of the fall or a result of the shock. At that moment you are hanging in your harness inertly which can cause a **harness suspension trauma**. This type of trauma occurs when you are suspended inertly in a harness, even for a short time, and can cause serious physiological harm. This is why, in case of an accident, it is important to intervene quickly with the appropriate technique.

Preparing for the worst

Before you work on heights or use fall arrest equipment, you need to be sure you can be rescued in case something goes wrong. When a fall occurs, and someone is hanging on a lifeline in a harness he/she needs to be **rescued as fast as possible**. The person hanging can have injuries from the fall, be unconscious or can suffer from a harness suspension trauma.

To be able to act fast, a **plan** must be in place to evacuate without panic. There must be people around that have been trained to evacuate and have the equipment to do so. The way someone is evacuated will depend on the situation. In some cases an unharmed worker can reach a ladder, in other cases he/she will need to be hoisted down if no other means of reaching him/her are available.

Equipment

The equipment to protect you against falls consists of a harness that is connected to a lanyard with a shock absorber that is connected to an anchor point.

Harness

There is a range of types of harnesses, depending on the use, the frequency and the specificity of the work. The most common one is the **multi-purpose full body harness**. A full body harness consists of straps passed over the shoulders, across the chest and around the legs. It **distributes** the force of impact over at least the thighs, pelvis, waist, chest, and shoulders. It is designed to be comfortable while working; used for fall-restraint, work positioning, rope-access, and fall-protection applications. The harness includes several means for attaching it to other components of a personal fall arrest system:

Pic. 4.5.1 Harness

- A dorsal connection point at the back for fall arrest
- A sternal connection point at the front at chest level for fall arrest
- A rear waist belt connection for restraint
- Side waist belt connection points for positioning
- A ladder climb connection point
- Extra loops to hang equipment

As you can see, every connection point has a specific purpose and should not be (mis)used for other purposes.

Connector

To connect your harness to the other components of you fall restraint or fall arrest system we need connectors. Of course these connectors need to be **as strong and safe as the rest of the system**. It is important to realise that the strength of a connector is only guaranteed if it is used in the proper way and in the **right direction**. All connectors need to have a locking system that ensures the connector can't open spontaneously.

The two types that are used most frequently in our sector are the carabiner and the snaphook.

Carabiner

The carabiner is used to connect the harness to the lanyard and to connect the lanyard to the anchor or static line wagon. It is only to be used in the length direction and has an automatic locking system. You have to make sure that no rope or other objects are obstructing the automatic locking system from closing.

Pic. 4.5.2 carabiner

Snaphook

A snaphook is used to connect the lanyard to **pipes or other large anchor points**. The opening is large enough to snap around the pipes. Snaphooks have an automatic locking system and you have to ensure there are no obstructions in the way of this system.

Pic. 4.5.3 snap hook

Lanyard

A lanyard is a finished length of flexible material used to connect a fall arrest harness to an anchorage point or static line. A lanyard assembly should be as **short** as reasonably workable to minimise the fall distance. A lanyard generally has a connector at each end for connecting the body harness on one side and a deceleration device, lifeline, or anchorage on the other. Sometimes, shock absorbers are integrated in the lanyard.

Adjustable lanyard

Lanyards can incorporate a designed mechanism that allows its length to be **shortened** or elongated. The lanyard can be adapted to different situations where anchor points or static lines for fall restraint are at different positions. This makes it possible to keep the length as short as possible.

Pic. 4.5.4 Adjustable lanyard

Twin-tailed lanyard

Twin-tailed lanyards allow users to remain protected while **transferring** between anchorage points. They are designed to connect to the harness with one connector, leaving two equal ends for the connectors that are used for the anchorage points.

Pic. 4.5.5 Twin-tailed lanyard

Shock absorber

Shock absorbers or energy absorbers are placed between the harness and the anchor point. They are designed to **limit the arresting forces** on the user in case of a fall. The shock absorber will unfold or extend to absorb the shock. It can increase the length of the lanyard it is connected to with (generally) 1.2 m. So this extra length has to be incorporated in the total fall height.

Pic. 4.5.6 Shock absorber

Anchor points and static lines

A fall restraint or fall arrest needs a fixed point that is **strong enough to hold the forces** to restrain a person or to arrest the force developed by a fall. Without a point that guarantees that it can withstand the forces, the whole system would not make sense.

The position of the point should be in relation to the risk and in accordance with the use. Some examples:

- The position will be part of the calculation of the **fall height**.
- The position should minimise the risk for a **swing** during the fall.
- When working in a cage, the restraint point should be **low**, to avoid climbing or falling over the railing.

It is important to note that the force on an anchor point will be several times higher to withstand a fall than when it is only used to restrain a person.

Certified anchor points

A certified anchor point is an engineered and certified point of attachment for lifelines, lanyards or deceleration devices. These points are **marked and labelled** for use with a retaining or fall arrest system. You will find these points in the cage of a person lift, for example.

Static lines

When the worker has to move a lot, for example on a lighting bridge, the single anchor can be replaced with a static line. This is a line or rail with a connector that replaces the anchor. The worker can now walk and the **anchor point will follow him/her**. Of course the line has to be designed to guarantee the safety at any position on the line.

Pic. 4.5.7 Static line

Improvised anchors

In some situations, like climbing a scaffolding tower, there will be no predesigned anchor points. In this case the worker needs to **decide by himself** whether a point is safe for attachment. The attachment point has to be unquestionably strong, without any deterioration, wear or sharp edges. And it has to be in the right spot to arrest the fall. Making this choice requires additional training.

Use

Using fall restraint or fall arrest systems safely depends on the smallest details. Remember **a chain is only as strong as the weakest link!** The detail you forget will become this link.

Preparing for evacuation

Before you use a fall arrest system, you need to understand the **emergency procedures**. Remember that there needs to be a person available to save a fallen person.

Checking before use

Before you put on the harness, you need to check the harness itself. This can be done based on a checklist adapted to your harness. General attention points will be:

- Manufacturers' **label** is present and shows the harness is suited for the purpose
- The **expiration date** is within limits
- No **missing parts**
- No **visible wear** of the material, no broken fibres, cuts, burns, pulled stitches, discoloration
- No **deformation or damage** of the buckles and D rings

You also need to check all the **other equipment** you are going to use, more specifically the lanyard, shock absorber, connectors and snap hooks. All these need to be checked for proper functioning, wear, deformation, manufacturers' label and expiration date. When you are ready with the checks, you can put the harness on.

Equipment that does not pass the check is taken **out of service** immediately, tagged to avoid further use, and reported to the person responsible for safety.

Putting on

A harness is a combination of shoulder and leg straps, buckles, and attachment points. The harness is designed to divide the forces applied on the attachment points over your body. This only works if the attachment points are at the right position and if all the straps are **tightened properly**. The harness has to fit perfectly. If it is too lose or too tight it can cause injuries. Check the manual to understand the correct order and procedure of putting on your harness.

One important remark: either wear your harness or take it off. Walking around with a harness that is not properly closed, gives a **false feeling of safety**. If you would need to secure yourself, it is possible you forget to connect and check it.

Check each other

It is hard to check if your harness is properly put on. Some parts are hard to see and you can't look at yourself from a distance. It is a good habit to **ask a colleague** to check if your harness is properly fastened and adjusted.

Use

Now you are ready to protect yourself while working on heights. The next step is using the equipment properly.

Going to the work spot

It is not enough to secure yourself when you are at the place you are going to work at. You also need to be safe **on the way** to this place. If you are moving to this place, you need to change anchor points the whole time. This is done with a twin lanyard. You always connect one of the ends before you release the other. This is called a 100 percent tie off.

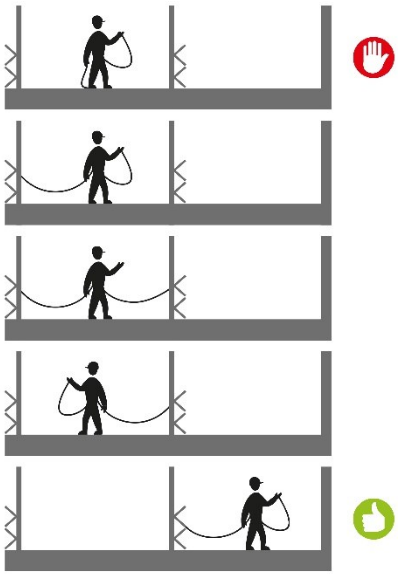


Fig. 4.5.b 100% tie off

Fall restraint

In case you use your equipment for fall restraint, you need to connect to the ring on your harness that is meant for this. You also need to attach your lanyard to a proper attachment point. The **length of your lanyard** should ensure there is no way you could come in a position where you could fall. With a fixed point, this will be rather clear, but with a static line you have to check if every point of the line ensures this limit.

When working in a bridge or cage where a fall restraint is required, you need to use a **low attachment point**. This low point ensures you can’t fall over the railing, while giving you the maximum space to work.

Fall arrest

If you use your equipment as fall arrest, you need to be sure there is **enough height to fall** (fall clearance distance). If not, you will hit the surface after all. If you fall, you will hang on your lanyard and the absorber will be in extended mode. As your harness is connected between your shoulders you need to add your own length as well. And it is always nice to have some safety distance. Usually, a length of 1 m is taken as extra distance. So the free height should be at least:

Fall clearance distance = Length of lanyard + maximum length of absorber + your height + safety distance

Don't forget to take into account possible **obstacles** on the ground. If there are for example flight cases on the ground under you, you need to add their height to the distance.

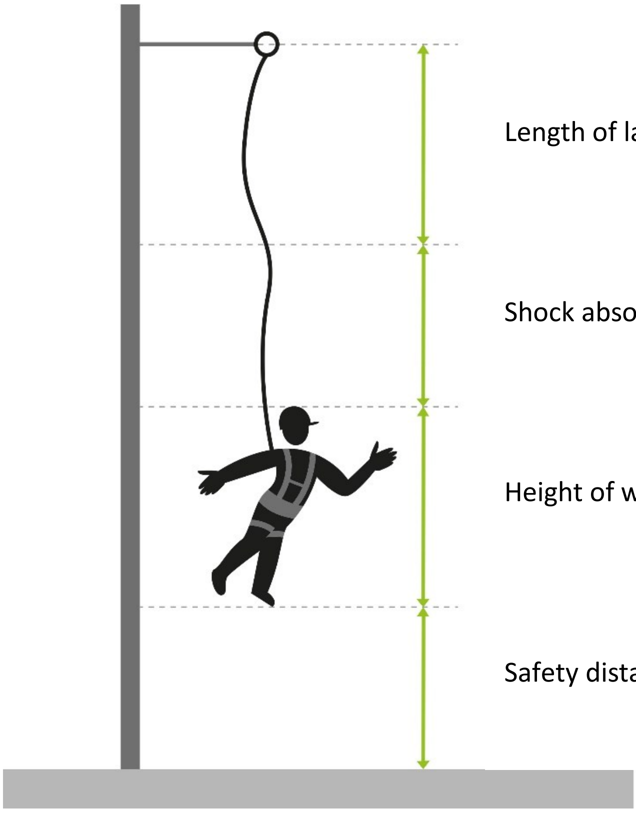


Fig. 4.5.c safety distance

You also want to keep the distance you fall (free fall distance) **as short as possible**. The longer the fall, the higher the shock you will need to absorb. Ideally this distance does not exceed 1.8 m. So it is important to keep your lanyard as short as possible.

If your attachment point is not directly above you, you also need to be aware of the risk making a **swing** when you fall.

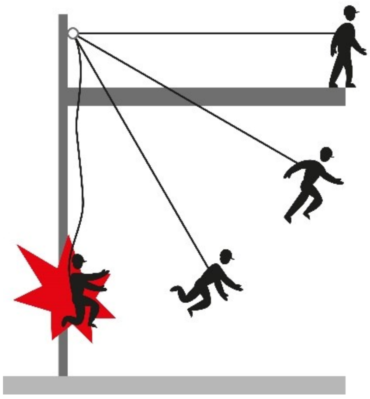


Fig. 4.5.d lanyard swing

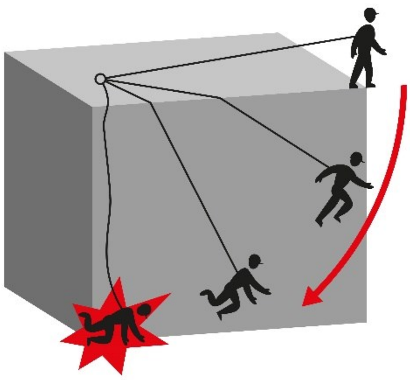


Fig. 4.5.e lanyard swing

After use storage and maintenance

After use, the equipment is checked again according the guidelines for pre-use. The equipment is also **checked** for stains, grease or other contaminants and **cleaned** if necessary. After the check, the equipment is **stored** in a safe and dry place.

Equipment that has been exposed to a shock load should be taken **out of service** until the person responsible for safety has decided to take it out of service permanently or not.

What you need to remember

You can only use the option fall protection after a risk assessment.
Measures taken after assessment come in the following order:

- Collective protection
- Fall restraint system
- Fall arrest
- Work positioning
- Rope access

You need to be trained to use the system on a regular base.
Before you work on heights or use fall arrest equipment, you need to be sure you can be rescued in case something goes wrong.

Terms and definitions

- collective protection
- fall restraint system
- fall arrest
- work positioning
- rope access
- harness
- carabiner
- lanyard
- snap hook
- shock absorber
- anchor points
- static lines
-

Rehearsal questions

04.05.01: A railing on a bridge is a type of

a) individual protection.
b) fall restraint.
c) fall arrest.
d) collective protection.

04.05.02: True/False

- A fall restraint system will absorb the shock when you fall.

04.05.03: True/False

- A fall arrest system will absorb the energy of falling.

04.05.04: What is the best solution if there is a risk of falling? (put in the right order)

a) Put a sign up, warning for fall risk
b) Eliminate the risk
c) Use fall arrest
d) Use collective protection
e) Use fall restraint

04.05.05: True/False

- There is no minimum height to use fall protection.

04.05.06: True/False

- A carabiner can be used in every direction.

04.05.07: True/False

- A lanyard should be as long as possible.

04.05.08: If you work in a cage, for example of a movable working platform, the attachment point for your fall restraint should be

a) as high as possible
b) as low as possible
c) doesn't matter

04.05.09: When working with a harness, you need to check each other

a) for liability reasons.
b) because you can't see all essential points.
c) because you can't trust your colleagues.

04.05.10: True/False

- A fall restraint system should be connected as high as possible.

04.05.11: True/False

- A twin lanyard is used to protect two people at a time.

04.05.12: True/False

- A 100% tie off means you are always connected with two lines.

04.05.13: True/False

- A fall arrest should be connected as high as possible.

4.6 Mandatory action signs

At the end of this block, you:

Recognize the mandatory action signs.

Mandatory signs indicate the **obligatory use of personal protection equipment**. These signs will help you to remember when to use the PPEs. But in the end, it is **your responsibility** to use them, even if they are not indicated. You will find the signs on doors, in workspaces as well as on machines. Being able to recognise the symbols will help you to identify the required PPEs, especially in an unknown environment like a foreign workshop or with new equipment.

The signs consist of **blue circles with a white image**. Sometimes, text is added to clarify or give extra information.

General mandatory action

This sign will always be combined with another sign or notice. It means you have to carry out the obligatory action on the accompanying sign or notice.

Ico. 4.6.1 General mandatory action

Eye protection

This sign indicates the obligatory use of eye protection. It means you need to use safety goggles or glasses adapted to the situation.

Ico. 4.6.2 Eye protection

Safety helmet

This sign indicates the obligatory use of head protection. It means you need to use a hard hat or bump cap depending on the situation.

Ico. 4.6.3 Safety helmet

Hearing protection

This sign indicates the obligatory use of hearing protection.

Ico. 4.6.4 Hearing protection

Respiratory protection

This sign indicates the obligatory use of breathing protection.

Ico. 4.6.5 Respiratory protection

Safety shoes

This sign indicates the obligatory use of safety shoes.

Ico. 4.6.6 Safety shoes

Safety gloves

This sign indicates the obligatory use of safety gloves. It means you need to use gloves adapted to the situation.

Ico. 4.6.7 Safety gloves

Body protection

This sign indicates the obligatory use of body protection. It means you need to use a clothes adapted to the situation.

Ico. 4.6.8 Body protection

Face protection

This sign indicates the obligatory use of face protection. It means you need to use a face screen adapted to the situation.

Ico. 4.6.9 Face protection

Individual safety harness

This sign indicates the obligatory use of a safety harness.

Ico. 4.6.10 Individual safety harness

What you need to remember

Mandatory signs indicate the obligatory use of personal protection equipment. The signs will help you to remember when to use the PPEs. The signs consist of blue circles with a white image.

Terms and definitions

- general mandatory action
- eye protection
- safety helmet
- hearing protection
- respiratory protection
- safety shoes
- safety gloves
- body protection
- face protection
- individual safety harness

Rehearsal questions

04.06.01: Match the signs with where you find them

1. Under a fly bar system
2. In high places
3. In noisy places
4. In a workshop

A B C D

04.06.02: This sign means:

a) Eye protection
b) Ear protection
c) Face protection

5 Prevent fire in a performance environment

To Prevent fire in a performance environment, you must:

Take the appropriate steps to prevent fire in a performance environment.

- This means you master following skills:
- Identifies, spots and reduces fire risks.
- Checks used materials for fire resistance.
- Ensures safe distance to hot surfaces.
- Ensures free access to firefighting equipment.
- Ensures free access to emergency exits and escape routes.
- Ensures visibility of safety icons, safety and emergency lighting.
- Acts according to the agreed procedure in case of a fire accident.
- Stores flammable substances according to instructions and regulations.

You master following knowledge:

- Fire theory
- Fire classes
- Risks of fire, smoke and CO
- Firefighting signs
- Evacuation routes and compartments
- Emergency escape or first-aid signs
- Properties of materials
- Safety distances
- (Storage of hazardous substances)

You have following attitudes:

- Safety awareness

Preventing fire is a task for **everyone** on (and around) the stage. It is part of our daily activities, even if most of the time the result is not visible. Hundreds of theatres have burned down in the past, most of them with extreme casualties. It is the risk with the most impact in theatre.

In all your activities, you need to constantly be **aware of fire risks**. Look for possible risks, spot issues that can be improved and reduce risks where possible. All materials on stage have to be fire retardant. Extra attention is especially required when new materials come in, even when they are rented or used from another company. Fire retardant materials ensure that fire does not spread and help to avoid a little fire becoming huge one.

Fig. 4.6.a Prevent-fire

Sometimes we create a situation on stage that goes against the logic above. For **artistic reasons**, open fire will be used, actors will be smoking, or explosive devices will be detonated on stage. All of these things are not allowed by "standard" fire regulation. But the organisation will sit together with the fire brigade and the safety staff to work out a safety plan, which brings these dangerous actions back **within the limits of safe work**. This means that for this special occasion different, extra procedures and special or additional safety provisions are set up.

We need to be ready for an **emergency** at all times. We need to be sure that there are emergency exits and evacuation routes in all circumstances and that firefighting equipment can be accessed and is ready to use. When storing equipment, you should spend special attention to avoid obstacles blocking firefighting equipment, exits and routes.

When installing or using equipment, ensure that you keep a **safe distance** between the appliance and materials that hold a fire risk, even when these materials are fire retardant. Especially equipment that becomes hot (spotlights, smoke machines, heating equipment) and equipment that has a hot focus point or beam (spotlights, lasers) are risk factors. But also poorly laid or damaged cables can cause enough heat to start a fire. If you feel that a plot conflicts with safe distances, and you are not able to solve the situation, notify a person who is responsible.

Pic. 4.6.1Mobile emergency equipment

Preparing for emergency

All the above are examples of actions that reduce the risks of fire. And apart from that, we also need to be prepared for the worst. We have to be ready if something goes wrong.

You need to know what to do **in case of an emergency**:

- What are the procedures?
- What do you need to do?
- What are the tasks of the others?
- Who communicates? Who decides?
- Who extinguishes the fire?

Ideally, you have answered all these questions and rehearsed all these actions in order to be prepared.

Each organisation will have an **emergency plan**, based on local or national regulations, that will clarify expected behaviour in case of fire.

If you get in a venue you are not familiar with, **check** the emergency and evacuation routes, it takes a couple of minutes and it can save your and other lives.

If a fire occurs, we want to evacuate the people in the building as swiftly as possible. This means **emergency exits and escape routes** have to be completely clear and free. And this goes for the staff as well as for the audience. Emergency routes are not storage places, not even for the smallest objects. One small object can be enough to make someone trip and create a larger obstacle for other escaping people.

To be able to escape, people need to find the exits and emergency routes. These are indicated with **emergency lights and icons**. It is obvious this only works if the lights are functioning and the icons are visible. Under no condition should they be covered. (Even if it is not your responsibility to ensure the proper functioning, it helps if you notify a responsible in case of malfunction.)

One of the most important things in case of a fire is containing it in one area. In theatres, **compartments** with fire doors are used to ensure this. These doors have to be closed at all times (or must be able to close in case of automatic closure). Never put an object in front of the door or keep it open with mechanical means.

Pic. 4.6.2 Fire door

In case of a fire, every second counts. The faster one can start extinguishing, the smaller the damage. So keep the **fire equipment** accessible. Do not put sets, flight cases, racks, etc. in front of fire equipment. It will slow down firefighting and enlarge the damage. On top of that, it is not allowed.

In case you discover a fire, the first question you have to ask yourself is whether you can extinguish the fire yourself. You can probably extinguish an initial fire that just started, but the moment it becomes larger, putting it out requires trained people. In any case, notify the responsible person or ask someone to raise alarm and warn a responsible. Never put yourself in danger.

In case of an **electrical fire**, unplug the equipment first or shut down power before extinguishing. If you can't extinguish the fire in a room, close windows and doors to contain the fire and leave the room.

Pic. 4.6.3 Fire poster

On tour

The above rules do not only apply to your work environment. If you are on tour for example, it is a good habit to **check** escape routes and fire equipment in the building, theatre, or event hall you are working in and also in your hotel. It takes a couple of minutes, but familiarity with the environment can save your life!

In case of an emergency

Some basic rules on how to behave in case of an emergency:

- Keep calm.
- Ensure your own safety.
- Secure the risk area.
- Evacuate injured people form the risk area if in danger.
- Make an emergency call.
- Perform first aid.
- Receive and support emergency staff.

Terms and definitions

- fire retardant.
- fire regulation
- evacuation
- emergency plan
- emergency exits
- evacuation routes
- firefighting equipment
- safe distances
- compartment
- fire door

Making an emergency call

If you make an emergency call, the operator needs specific information to be able to respond and to send the right services to the right place.

- Who are you?
- Where are you?
- What type of incident happened?
- What types of injuries are there?
- How many injured people are there?

5.1 Fire theory

At the end of this block, you:

- Understand how a fire arises, develops and behaves.
- Understand how fire can be prevented.

Fire is a **chemical reaction** that occurs when **fuel, oxygen and an ignition source** come together in the right proportions. This combination is represented in the fire triangle.

This also means that **if we remove one of the elements or change the proportion, the fire will die out**.

Pic. 4.6.1 fire triangle

Fuel materials

Fuel materials are present everywhere in our work environment. Sets, props, curtains, dust, cleaning fluids, gas etc. are obvious examples. The fuel can be **solid, fluid, gas or even metal**. In most cases it is not the materials that will burn, but the gases or fumes that are released when the materials are heated. These gases or fumes float above the surface of the materials.

Oxygen

Oxygen is omnipresent in our lives, it is part of the air we breathe. In normal circumstances the air contains 21 % of Oxygen. If we lower the amount of oxygen, the fire will reduce, and if we add oxygen the fire will grow. The exposure of a material to oxygen will influence how easily it burns. For example a sheet of material will far less easily burn when it is lying flat on the floor, than when it is hanging vertically and the oxygen can reach it from all sides. This is also a result of upward moving hot gasses, of course.

Ignition source

The ignition source provides the energy to start the fire. Examples of ignition sources are open flames, overheated cables or surfaces, heat of spotlights or their beams, sparks, a cigarette,… It is important to know that in order for materials to ignite, they don't necessarily need to be in **direct contact** with flames or the actual heat source. Heat can also be transferred by **conduction** (i.e. by a metal beam), by **convection** (upward movement of hot air or smoke) or by **radiation** (i.e. heat radiated from a spotlight).

Development of fire

Starting small, a fire can expand into a major incident very fast. The initial fire will function as an ignition source for the surrounding materials and will heat them up so they **develop gasses** that will also burn. Hot gas (smoke) that is not fully burned yet will spread and create a risk for a **flash over**, which could ignite a whole room. Once the fire is fully developed, unburned gases accumulate at the ceiling level and often burn as they leave the compartment, resulting in flames showing from doors or windows. Once the available fuel is consumed, the fire will slowly decline.

Fig. 5.1.a Prevent-fire

It should be clear that the best chance to extinguish the fire is during the **initial phase**, when the fire has not yet inflicted the surroundings. A fast response is required to keep the fire under control.

Flash point

The flash point of a chemical substance is the **lowest temperature** at which enough fluid can evaporate to form a combustible concentration of gas. The flash point is an indication of how easy a chemical may burn. Materials with higher flash points are less flammable or hazardous than chemicals with lower flash points.

Some examples:

- Acetone 0°
- Lighter fluid: 4°
- Cleaning ethanol 16.6°

Spontaneous combustion

Some materials like linseed oil can create heat in combination with oxygen. Linseed oil is used in paints and as a finishing product for outside furniture. If the linseed oil is on something flammable (like a rag you might use to clean furniture), it can catch fire with no outside spark at as low as 120 degrees. We call this **auto-ignition**.

Explosion

Situations with risk for explosion are rare in a performance environment. Two particular types of explosions occur, mostly on purpose, but with a risk of unwanted explosion as well.

Dust explosions

A dust explosion is the rapid combustion of fine particles suspended in the air, often but not always in an enclosed location. Dust explosions can occur when any **dispersed powdered combustible material** is present in high enough concentrations in the atmosphere or other oxidizing gaseous medium such as oxygen. This can happen, for example, when coloured powder is used to spread over the audience during events.

On the other hand, special effects artists, filmmakers, and pyro technicians also commonly use dust explosions because of their spectacular appearance and their ability to be safely contained in certain carefully controlled conditions.

Pyrotechnics

Pyrotechnic materials are often used in a performance environment. Materials used in pyrotechnic devices can be highly flammable or oxidising. By their nature, these used materials are highly explosive and can be ignited **by heat as well as by sparks**. The storage, manipulation and use of pyrotechnics is a specialist's work.

Gas tanks

Next to this, gas systems used to fuel pyrotechnics can present a serious risk. Not only can the gas leak and form an **explosive mixture**, but the tank itself can also **explode** when in a fire. The storage, manipulation and use of gas tanks is a specialist's work.

Preventing fire

The prevention of fire is a result of the above. Avoiding a combination of factors occurring is the best fire prevention.

- In the first place, we will **minimize the amount of combustible material**, the fire load. We will avoid flammable liquids, untreated wood or curtains, but also avoid dust, etc.
- Secondly, we **avoid ignition sources** like open flames, cigarettes, sparks,… but we will also ensure the distance to hot surfaces.
- The use of **oxidising products** in a performance environment is rare, so the possible measures that can be taken are limited here.

What you need to remember

Fire is a chemical reaction that occurs when fuel, oxygen and an ignition source come together in the right proportions. If you take away one of these elements, the fire stops.

- To prevent fire:
- Minimise the fire load.
- Avoid ignition sources.
- Avoid oxidising products.

Terms and definitions

- fire
- fuel
- oxygen
- ignition source
- open flame
- conduction
- convection
- radiation
- flash point
- dust explosion
- spontaneous combustion
- pyrotechnics

Rehearsal questions

05.01.01: True/False

- Fuel for a fire can be a metal.

05.01.02: True/False

- We can reduce a fire by adding oxygen.

05.01.03: True/False

- A fire can start by radiation.

05.01.04: True/False

- The flash point is an indication of how easily a chemical may burn.

05.01.05: True/False

- Dust lying on the floor can explode.

5.2 Fire classes

Before you start, you should read 05.01 Fire theory .

At the end of this block, you:

- Can recall the different fire classes used in Europe.
- Understand the differences between the fire classes.
- Can determine the class of a fire.
- Can recognize the symbols used for the different fire classes.
- Can recall the extinguishing methods for each class..

In Europe, we divide fires into five (or six) classes. Each class stands for a different **type of fire**, based on the combustible material. This classification is necessary to indicate the extinguishing method that should be used. This is very important since the wrong extinguishing method could increase the fire and put you in extreme danger. The classes are represented by a **class character and a symbol** (icon). In theory, energised electrical fire (the sixth class) is not part of the classification. It has no character, but the symbol is added to other fire types.

We will only cover the most common fire extinguish methods, like using water, sand, dry powder, foam, co2 and fire blankets. Specific extinguishing methods are developed for specific situations, but getting into this would lead us too far for the purposes of this text.

Class A fires

Class A fires involve ordinary **solid combustibles**. We call them dry fires. Examples are organic solid materials like paper, wood, cloth, rubber, fabrics, plastics, most kinds of trash etc. They are the most common materials you will find in the home, workshop, or stage. Class A fires can be extinguished with water, foam or dry powder (ABC powder). A fire blanket can be used for people on fire.

Ico. 5.2.1 Class A fire

Class B fires

Class B fires involve **flammable liquids or liquefiable solids**. Examples are petrol, solvents, oil, alcohol, acetone, paint and also some waxes, plastics, rubbers, paraffin and bitumen. Cooking fats or oils are excluded (when they are used in a kitchen environment). The temperatures reached when burning require specific extinguishing methods. They form a specific class (F). Class B fires can be extinguished with powder (ABC), CO2, foam or sand. A solid stream of water should never be used because it can cause the fuel to scatter, spreading the flames.

Ico. 5.2.2 Class B fire

Class C fires

Ico. 5.2.3 Class C fire

Class C fires involve **flammable gases**. Examples are natural gas, LPG, hydrogen, acetylene, methane, propane or butane. Before extinguishing, the gas supply needs to be closed. If the supply would stay open, the gas would continue flowing and could build an explosive mixture in a confined space. The fire itself is extinguished with dry powder or CO_2.

Class D fires

Ico. 5.2.4 Class D fire

Class D fires involve **combustible metals**. Examples are sodium, magnesium, titanium, aluminium, lithium, and potassium. Alloys of these metals can burn as well. These fires are uncommon and usually found in an industrial setting. They represent a unique hazard because people are often not aware of the characteristics of these fires and are not properly prepared to fight them. Water and other common firefighting materials can excite metal fires and make them worse. To extinguish metal fires, specific dry powders (like L2 or M28) are used. This powder will smother the fire and absorb the heat.

Electrical Fire (Class E)

Ico. 5.2.5 Electrical fire

Technically, electrical fires don't exist. **Electricity doesn't burn**. This is the reason the "electric fire class" is taken out of the European class system. The symbol is still in use for fires involving potentially **energized electrical equipment**. Examples are fires fuelled by electrical appliances such as switchboards, dimmers, projectors, smoke machines, TVs, computers, and hair dryers. This type of fire may be caused by short-circuiting machinery or overloaded electrical cables. The materials that burn are the same as class A or class B fires, but the potential presence of electricity limits the extinguishing methods. Water, foam or other conductive substances cannot be used. This could cause an electric shock. The fire can be extinguished with Carbon dioxide (CO_2) or dry powder. In most cases, CO_2 is preferred for small fires, to avoid damage to adjacent electronic equipment. Once the power to the equipment involved is switched off, it will become an ordinary combustible fire.

Class F fires

Ico. 5.2.6 Class F fire

Class F fires involve **cooking oils or fats**, mostly in a kitchen environment. The temperature that is reached in this type of fire exceeds that of other flammable liquids by far. Normal fire extinguishing methods should not be used. Water for example would provoke ejection of a plume of burning liquid fluid in the air. Covering the fire with a blanket or specialised (wet chemical) extinguishers can be used to put out the fire.

Outside of Europe

Fire classes are not the same all over the world. Even if the basics are the same, small differences exist between Europe, the US and Australia. So if you are on tour, have a close look at the extinguishers.

Type	Europe	United States	Australia
Combustible materials	A	A	A
Flammable liquids	B	B	B
Flammable gas	C	B	C
Flammable metals	D	D	D
Electrical fire	(not classified)	C	E
Cooking oils and fats	F	K	F

What you need to remember

- Class A fires involve ordinary solid combustibles.
- Class B fires involve flammable liquids or liquefiable solids.
- Class C fires involve flammable gases.
- Class D fires involve combustible metals.
- The symbol for electrical fire is still in use for fires involving potentially energized electrical equipment.
- Class F fires involve cooking oils or fats, mostly in a kitchen environment.

Terms and definitions

- fire class
- extinguishing method
- combustible material
- solid combustibles
- fire blanket
- flammable liquids
- powder (ABC)
- CO2
- flammable gases
- combustible metals
- cooking oils
- electrical fire

Rehearsal questions

05.02.01 Connect the material with the icon

1. LPG (Liquified Petrol Gas)
2. A dimmer on fire
3. Car wheels
4. Deep fryer
5. A set
6. A box of solvent cleaning products

A B C D E F

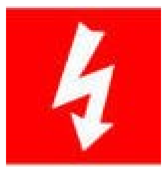
05.02.02 A dimmer flight case is on fire, the head electrician already disconnected the power cable. This is a

a) electric fire
b) class B fire
c) class A fire

05.02.03 Some stage hands have been degreasing and greasing the gears of spotlights. They spilled some product. There is a risk for a

a) class F fire
b) electric fire
c) class B fire

05.02.04 If this symbol is on a fire extinguisher you



a) should never use it on electric equipment.
b) should only use it on electric equipment.
c) can use it on the class mentioned next to it when the equipment is still powered.

5.3 Risks of fire, smoke and CO

Before you start, you should read 05.01 Fire theory .

At the end of this block, you:

- Understand the effects of fire, smoke and CO on the human body.
- Understand the effects of fire, smoke and CO on the spreading of fire.
- Understand the effects of fire, smoke and CO on the stability of sets.
- Understand the effects of fire, smoke and CO on rigging systems.
- Understand the effects of fire, smoke and CO on the building.

Fire is dangerous, that is very obvious, but the **smoke** that comes with it, is equally dangerous. The risk of smoke must not be underestimated. That is why it is not only important to know about the risk of fire, but also about the risk of smoke and how smoke can make a fire worse.

Fig. 5.3.a Fire-risk

Effects on the human body

Here we describe the effects that smoke and fire can have on a human body.

- Fire produces smoke that spreads fast in a building. Smoke contains **toxic** elements like CO. Inhaling of a small amount of smoke can make you dizzy or out of breath. We call this intoxication. This can influence your behaviour in an evacuation. Some products (mainly plastics) will produce a more toxic smoke than others.
- The smoke is very **hot**. Inhaling hot smoke can cause internal burn wounds in the lungs.
- The fire and the smoke take away the oxygen in the air. Without oxygen your lungs can't produce energy for your body. In extreme cases, you may **suffocate**.
- The smoke is an impenetrable black. It limits the **visibility**, but also your **hearing**. This can disorient you in case of an emergency. When dealing with an audience, the lack of visibility and hearing can cause panic. People will start to push to get out and when someone trips, he becomes an obstacle for others. Because of a lack of oxygen, combustion can be incomplete, causing more and darker smoke to be produced while also containing a larger amount of CO.
- Direct contact with fire causes **burns**. But hot surfaces, hot combustion gases and radiation can cause burns as well. There are different degrees of burns. The degree depends on the damage of the skin. First-degree is the lowest damage and results in red, non-blistered skin. Second-degree burns cause blisters and some thickening of the skin. Third-degree burns show widespread thickness with a white, leathery appearance.

Effects on spreading the fire

Smoke can move easily from one part of a building to another. Because it is so hot, it can also spread the fire to other parts of a building. The smoke contains **carbon and non-burned particles** that function as fuel again. This is the reason we want to contain the smoke in one part of the building.

Fire will not only spread by smoke, but also by **radiation and heat conductive** materials such as steel beams. This means that smoke can act at a distance, without direct contact with flames. Also materials that melt and produce hot or even burning droplets are an important factor in spreading the fire.

The heat of the fire will also have an effect on **objects that are in the space**. Canisters and containers can explode and the product inside can feed the fire. Pyrotechnics can ignite and air tanks can overheat and explode.

Effects on the stability of sets

The produced heat and the fire itself can affect the **structural strength** of a set. This can cause floors to collapse or sets to fall over. Wooden floors and structural elements can burn. They will become weaker and at some point collapse. Metal structures can start bending or even melting when the temperature rises. Once a structure loses stability and starts moving, the forces will increase and the structure will collapse. The strength of a structure is only as strong as its weakest point.

Effects on rigging systems

Rigging systems are mounted at the highest point of the theatre, where the heat is the highest. This makes them vulnerable for destruction by heat. The rigging systems are mostly constructed in a combination of metal and aluminium that will start **bending or even melting** in these conditions. Steel cables and slings can break or the connections can melt. This causes the structure and the equipment it supports to come down.

Effects on the building

A big fire will also influence the **structural strength and stability** of the building. Even if a building is divided in compartments, these will only hold for a limited time. In the end, the whole building will be destroyed.

Tips to escape

- If you have to escape, stay low on the ground, there you have the most chance for oxygen.
- Before opening a door, feel if the door handle or the surface of the door is hot. If it is hot, there could be a fire behind it. Don’t open the door!
- If you have to open a door when in doubt, stand to the side instead of in front of it.
- Use the back of your hand to find your way in the dark. If you would touch an electrical conductor, your muscles will contract, but you won’t get cramped around the conductor.

How to deal with burns

If someone has a burn from flames or heat, the first thing to do is to stop the burning. This can be done by covering the fire, using water, or rolling over the floor to stop the flames. Next, you need to cool down the wound. Run cool tap water over it for about 10 to 20 minutes. The water should not be too cold or icy. Use clean water if possible, but when this is not available, even dirty water is better than not cooling at all. This also works for burns from plastic or tar-like products. Burns caused by cold temperature, chemicals or electrocution need to be treated differently.

Source: http://www.webmd.com/first-aid/tc/burns-home-treatment

Did you know?

Burns cannot only be caused by fire. There are other causes, but they are less frequent.

- Thermic burns (heat, freezing)
- Electrical burns (electrocution)
- Chemical burns (acids, alkali)
- Radiogenic burns (sun, radiotherapy)

Source: http://www.brandwonden.be/index.php/epidemiologie/nl/

What you need to remember

- Smoke causes burns, intoxication, suffocation and limits the visibility and hearing.
- Fire spreads by smoke, radiation, heat conduction and melted droplets.

Terms and definitions

- fire
- smoke
- CO
- intoxication
- burns
- combustion gas
- structural element
- compartment
- rigging systems
- structural strength

Rehearsal questions

05.03.01: True/False

A first-degree burn cause blisters and some thickening of the skin.

05.03.02: Smoke influences your (multiple answers)

a) Hearing
b) Balance
c) Vision
d) Touch senses

05.03.03: True/False

- Burning plastics produce toxic smoke.

05.03.04: True/False

- Rigging systems are vulnerable for destruction by heat, because they are mounted at the highest point of the theatre, where the heat is the highest.

5.4 Firefighting signs

At the end of this block, you:

- Recognize the firefighting symbols.

Firefighting signs indicate the place of firefighting equipment and alarm facilities. The signs are **red squares with a white image**. Sometimes, text is added to clarify or give extra information.

In a performance environment, the signs should also warn staff to ensure the access ways to the equipment remain free.

Fire extinguisher

This sign indicates the location of a fire extinguisher.

Ico. 5.4.1 Fire extinguisher

Fire hose

This sign indicates the location of a fire hose reel.

Ico. 5.4.2 Fire hose

Fire ladder

This sign indicates the location of a fire ladder. This is a ladder that is exclusively used for firefighting.

Ico. 5.4.3 Fire ladder

Fire equipment

This sign indicates the location of firefighting equipment. This sign can refer to all sorts of equipment like buckets of sand or hooks.

Ico. 5.4.4 Fire equipment

Fire alarm

This sign indicates the position of a fire alarm call point. This is a button that activates the fire alarm.

Ico. 5.4.5 Fire alarm

Fire phone

This sign indicates the position of a fire emergency phone. This type of phone will give you direct access to the fire brigade or the responsible staff member that deals with fire emergencies.

Ico. 5.4.6 Fire phone

What you need to remember

Firefighting signs indicate the place of firefighting equipment and alarm facilities. The signs are red squares with a white image. Sometimes, text is added to clarify or give extra information.

Terms and definitions

- fire extinguisher
- fire hose
- fire ladder
- fire equipment
- fire alarm
- fire phone

5.4.1 Rehearsal questions

05.04.01: Match the signs with where you find them

1. Fire extinguisher
2. A shelf with fire vests and axes
3. A push button
4. Fire reel


A


B


C


D

04.06.02: This sign means:

a) Do not use phone in case of fire
b) A direct line to the fire brigade
c) Phone will ring in case of fire

5.5 Evacuation routes and compartments

Before you start, you should read the chapter 05.01 Fire theory.

At the end of this block, you:

- Understand the principles of compartments and emergency routes.
- Understand the use of safety and emergency lighting..

Theatre and event spaces are not only used by permanent workers, but **also by freelancers, audience, guests**,… In total, this is a large group of people of which many are not acquainted with the situation. Depending on the moment, the space will have different functions. It can be a workspace, an audience place,… On top of that, some spaces have several functions at the same time. During the set-up, other activities can happen in the house, an audience will visit an exhibition in the hall or listen to a lecture in a foyer, or rehearsals can go on in the café.

Precautions for emergency

The first priority in case of a calamity is to evacuate, to bring all people out of the risk zone. In practice this will mean taking them out of the building. You could ask why we spend so much effort for **emergency planning**, as there are not that many theatre fires or other calamities. The reason is that the consequences in most cases are very dramatic and disastrous.

To be able to evacuate efficiently, different measures are taken in a building or an event space and people are appointed to perform safety tasks.

Compartmentation

A large building, especially when receiving an external audience, is split up into different parts, called compartments. These compartments have **fire proof walls** to limit the spreading of fire and smoke. This buys time for the people inside to evacuate.

Special attention is given to staircases, they are typical evacuation routes, but also connect different levels and create a **chimney effect**. Like a chimney, the staircase creates an air stream exciting the fire. Staircases will always be a separate compartment to avoid this effect.

In spaces with a chimney effect (staircases, fly towers, etc.) **smoke hatches** are placed to evacuate the smoke. These should only be activated by a fire responsible. Opening the hatches at the wrong moment could enlarge the fire.

Fireproof doors

Fireproof doors are placed **between fire compartments**. These doors form the final closure of the compartment. They need to be closed permanently or close automatically when there is a fire. Most fire doors close automatically with a closing device. In everyday use, they can be kept open with an electrical door holder's magnet. This is an electromagnet that is turned off by the fire alarm, allowing the door to shut, in the event of a fire.

Under no circumstances should the fireproof doors be **blocked or kept from closing**. The compartmentation would be lost and the fire could spread over the building. A cable running through the door or a wedge to keep the door open are recipes for disaster.

Fireproof doors are recognizable with a **mark in the side of door**. In most countries, there will also be a warning on the door.

Fig. 5.5.a Evacuation

Iron curtain

In theatres with a stage tower, the stage opening is closed with an iron curtain when the building is not used. This iron curtain will also be lowered in case of fire, creating a (limited) compartment consisting of the stage by separating it from the audience house. It will also **limit the chimney function** of the fly tower towards the audience space.

Breaking the compartment

Fire crosses the compartment walls through the smallest holes. Drilling a hole for cables or for passing pipes should only be done by professionals that are able to ensure the integrity of the compartment.

For temporary cables, holes are made that are filled with **fire bags**. These fire bags will swell in case of a fire closing off the hole and guaranteeing the compartment's integrity.

Evacuation routes

Evacuation routes ensure that people can flee in a safe way, without passing other danger zones and bring them to the outside of the building. People tend to leave a room the way they came in, so the primary evacuation routes are the standard exits. The emergency routes guarantee that even when normal access routes are blocked, for example by fire, people can **leave the building safely**. The routes are not only used in case of fire, but can also be used during other calamities.

The routes are marked with signs and lit with emergency lighting. They form a separate compartment and support a "natural flow" of people.

Evacuation doors

Pic. 5.5.1 emergency lock

The doors in the evacuation route always open **in the fleeing direction**. Under no condition should the doors be **locked** in the fleeing direction when the building is in use. Special push bars are put on the doors to ensure they open when a crowd is pushing to get out. In some countries special emergency locks are used for exits with smaller amounts of people.

A conflict between safety and security

In many cases a conflict between safety and security will arise in a public building. For safety reasons, we want to keep all doors unlocked, but for security reasons we want all the doors to be locked. In all cases we will need to take both points of view in account. Solutions like door alarms or electric locks that open in case of fire or power failure will help reconcile both parties.

Gathering point

Pic. 5.5.2 reassembly point

An evacuation route ends at a gathering point. This is the place where all people come together **after evacuation**. They will be given first aid, will be counted and will receive further instructions. The place is chosen in such a way that the evacuated people will not hinder the emergency services.

How people flee

In case of an evacuation, there is always a risk that panic arises. The combination of fire, smoke, limited visibility, but also rumours can awaken the reflex to flee. At that moment, you can't expect normal, rational behaviour. People will literally fight for their survival, even if this has a negative effect on the evacuation.

Safety and emergency lighting

What is generally called emergency lighting has in fact several functions. In a lot of cases these functions are combined in one fixture. The different functions are:

- Visibility in **normal circumstances**
- Visibility of **signs**
- Visibility in **emergency circumstances**

Most audience spaces in theatres and venues need to be dark in normal circumstances, we want the focus on the light on stage. But on the other hand, we need **minimum lighting** to ensure that an audience member that feels ill or wants to leave the house can do so safely. The safety or maintained lighting will not only include normal emergency fixtures, but also stair lighting and sometimes floor (aisle) lighting. It needs to be on when an audience is in the house.

Secondly, we need to ensure that the **exit and evacuation signs** are visible the whole time. This can be done by hanging the fixtures above the signs or by integrating the signs in the fixture.

The emergency function is activated when there is a **fire or a power loss** in the house. At that moment, the fixtures will work on an autonomous power supply (battery) or a separate power net.

The light of the fixtures is strong enough to evacuate the audience and the workers out of the building.

In temporary venues or in situations where emergency lighting is blocked by sets or other interventions, temporary emergency lights will be added to ensure safe evacuation.

To be certain the fixtures will work when needed, they will be tested on a regular base. Some systems will perform these tests automatically.

It will be clear that the fixtures should always be visible and should not be masked or covered. This would endanger yourself, your co-workers and the audience.

Keep the routes free

If someone would fall in a hectic situation with panicking people, he/she forms **an obstacle for the others**. The risk that more people would fall and enlarge this obstacle is realistic and can lead to a disaster.

Therefore evacuation routes should be **completely free of obstacles**. Chairs, plinths, objects, … should be removed from the evacuation route. Mixing desks, cameras, projectors, … have to be placed outside the route. Wheel chairs need to be placed in determined positions and extra chairs should not be allowed.

But also on the **outside of the building**, we need to be sure that no obstacles are in the way of the fleeing people. Emergency doors should be able to open completely and a free passage to the gathering point should be ensured. Typical examples are emergency doors blocked by parked cars.

Fig. 5.5.b Hallway

Temporary constructions

Temporary constructions, cable routes or vending stands should not block escape routes. But also **on stage** we have to make sure that sets or other constructions do not block routes. We need to ensure that actors and technical staff can leave in a safe way in case of emergency and that we keep access to all areas free for fire fighters.

Colleagues in odd places

Fig. 5.5.c Burning-stage

Evacuation routes are not only for the large audience, but also for every individual worker. This is especially important for people working in odd places where it is less obvious to evacuate. You can think of:

- People working in the **fly tower**
- People working in the **under stage**
- People working **in or on top of sets** during performance

This means the evacuation possibilities have to be taken into account for these specific situations and should be part of the risk assessment.

Open air

In open air, the same principles apply, but they are less focused on fire and more on other events like spontaneous movement of large crowds, weather conditions, etc.

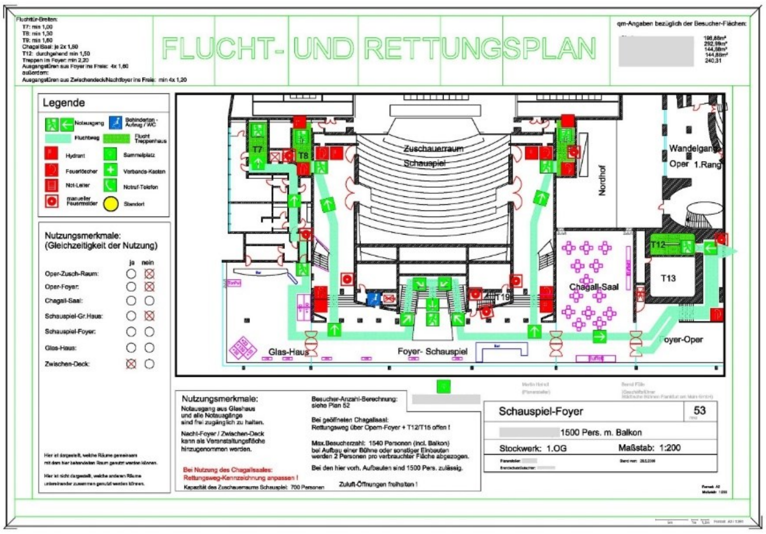
Crush barriers

Crush barriers are mostly used in open air to limit the amount of people per block and to avoid people getting crushed when large amounts of people are moving in one direction, for example to the stage. In large indoor venues this is mostly done by structural parts of the building.

Regular checks and documentation

In some countries checking the evacuation routes is part of an everyday routine, before opening for the public. In other countries, this is done on a regular, periodic base. But keeping the emergency routes obstacle free and ready to use remains a **(moral) responsibility** for everyone.

The evacuation routes have to be documented (see example) and the persons involved have to be trained on a regular base, to be able to participate in the evacuation process when needed.



Pic. 5.5.3 Evacuation plan

Properties, standards and measurements

Properties, standards and measurements for evacuation routes and doors depend mainly on **national regulations**. But the principles behind them and they way they are expressed are the same.

The **width of evacuation routes** is expressed in cm/person with a given minimum width. This is always the requirement for the narrowest point in the route. This value will be multiplied for ascending or descending routes with an extra factor.

For example, in Belgium an evacuation route is minimum 1 cm per person (in flat route), multiplied with 1.25 for descending routes and 2 for ascending routes. The minimum width is 90 cm.

The **amount of required routes** depends on the total capacity of the building. In larger spaces, multiple routes will be required to guarantee safe evacuation, even if one of the routes is blocked.

For spaces with fixed seating, the **maximum amount of chairs in a row** is a given. This is the amount of chairs a person has to pass before getting to a normal width corridor.

The fire resistance of fire doors is expressed in **fire resistance time**. In other words, how long will the fire be stopped by a properly closed door? Typical values are 1 h or 2 h.

The **maximum capacity of a space** is decided based on the combination of all factors, including emergency exits, space per person, type of use, etc. This maximum capacity is calculated including workers. So for example a choir, orchestra, volunteers, … influence the maximum allowed amount of audience.

If a space is **used in a different way**, for example by seating the audience on stage, the entire emergency plan and the calculation of maximum capacity need to be revised. This will be done by the safety responsible of the house.

What you need to remember

The first priority in case of a calamity is to evacuate. To be able to evacuate efficiently, different measures are taken in a building or an event space and people are appointed to perform safety tasks.

- The building is split up in compartments.
- Fireproof doors are placed between fire compartments.
- In theatres with a stage tower, the stage opening is closed with an iron curtain.
- Evacuation routes and doors are kept free.
- Safety and emergency lighting is ready.
- People are appointed to perform specific tasks in case of emergencies.
- Evacuation procedures are trained.

Terms and definitions

- calamity
- evacuation
- compartment
- chimney effect
- fireproof door
- evacuation door
- iron curtain
- emergency route
- safety
- security
- gathering point
- panic
- safety lighting
- emergency lighting
- crush barriers

Rehearsal questions

05.05.01 A large building is split up in compartments

a) because otherwise everybody will go everywhere.
b) to contain the fire in one area.
c) to guarantee security.

05.05.02 A fire proof door

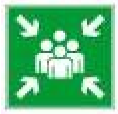
a) is a door in a emergency route.
b) is a door that withstands the fire for a time.
c) is a door that leads to the outside.

05.05.03 An evacuation door

a) is a door in a compartment.
b) is a door that withstands the fire for a time.
c) is a door that leads to the outside.

05.05.04: True/False

- This sign is put at the place where the emergency crew gathers before an intervention.



05.05.05 Safety lighting

a) always has to be turned on.
b) has to be turned on if audience or workers are in the building.
c) has to turn on if the power supply fails.

05.05.06 Emergency lighting

a) always has to be turned on.
b) has to be turned on if audience or workers are in the building.
c) has to turn on if the power supply fails.

05.05.07 Emergency routes

a) can only be used as storage for a short time.
b) can be used as storage is there is enough light to escape.
c) can never be used as storage.

5.6 Emergency escape or first-aid signs

At the end of this block, you:

- Recognize the escape route symbols..

Evacuation signs indicate **evacuation routes**, but they also point out where **safety equipment** and **facilities** are. They also appear on evacuation plans. Being able to recognise the symbols will help you to escape safely, especially in an unknown environment like a foreign theatre or hotel.

The signs are **green squares with a white image**. Sometimes, text is added to clarify or give extra information.

In a performance environment, the escape route signs are often combined with emergency lighting to ensure they are visible in the dark. Sometimes photoluminescent (glow in the dark) versions are used as a simple and effective solution.

Emergency exit

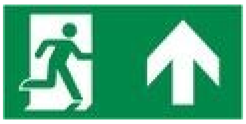
These signs indicate an escape route to a safe place.

Ico. 5.6.1 Emergency exit left

Ico. 5.6.2 Emergency exit right

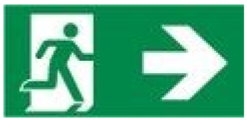
These signs are combined with arrows explaining the direction

Ico. 5.6-3 Downward exit



Ico. 5.6-4 Forward or upward exit

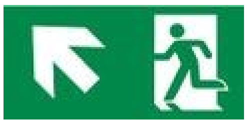
Ico. 5.6-5 Exit to the left



Ico. 5.6-6 Exit to the right

Ico. 5.6-7 Downward exit to the stairs left

Ico. 5.6-8 Downward exit to the stairs right



Ico. 5.6-9 Upward exit to the stairs left

Ico. 5.6-10 Upward exit to the stairs right

First aid

This sign indicates the location of a first aid post, first aid set or first aid staff.

Ico. 5.6-11 First aid

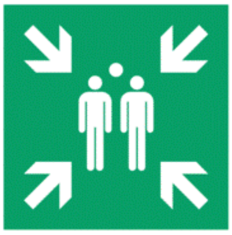
Emergency telephone

This sign indicates the place of an emergency phone. This is a phone that connects directly to the emergency services or to a staff member in the building responsible for emergency actions.

Ico. 5.6-12 Emergency telephone

Assembly point

An evacuation assembly point shows staff and members of the audience the place to go in case of an evacuation. At this place, the evacuation responsibles will check if everybody left the building and is accounted for. The evacuation points are at a safe distance from the building.



Ico. 5.6-13 Assembly point

Break to obtain access

This sign is placed at **covers that need to be broken** in case of an emergency to obtain access to emergency exit devices.

Ico. 5.6-14 Break to obtain access

Doctor

This sign indicates the location of a doctor.

Ico. 5.6-15.6 Doctor

Defibrillator

This sign indicates the location of an automated external heart defibrillator. This is an automatic device that can be used in case of a heart attack.

Ico. 5.6.16 Defibrillator

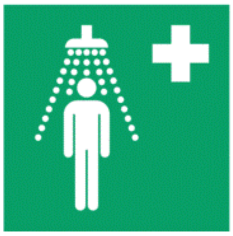
Eye shower

This sign indicates the location of an eye shower or an eye wash station. These can be used in case of **spill of chemical products or small objects** in the eye.

Ico. 5.6-17 eye shower

Safety shower

This sign indicates the location of a safety shower. The shower can be used in case of **spill of chemicals on clothes**.



Ico. 5.6-18 Safety shower

Stretcher

This sign indicates the location of a stretcher.

Ico. 5.6-19 Stretcher

Escape ladder

This sign indicates the location of an emergency window.

Ico. 5.6-20 Escape ladder

Rescue window

This sign indicates the location of a rescue window.

Ico. 5.6-21 Rescue window

Unlock counter clockwise or clockwise

These signs indicate in what direction the doorknob of a door in an escape route needs to be turned to open.

Ico. 5.6-22 Unlock counter clockwise

Ico. 5.6-23 Unlock clockwise

What you need to remember

Evacuation signs indicate evacuation routes, and point out where safety equipment and facilities are. The signs are green squares with a white image. Sometimes, text is added to clarify or give extra information.

Terms and definitions

- emergency exit
- first aid
- emergency telephone
- assembly point
- break to obtain access
- doctor
- defibrillator
- eye shower
- safety shower
- stretcher
- escape ladder
- rescue window
- unlock counter clockwise / clockwise

Rehearsal questions

05.06.01: Match the signs with where you find them

1. Above a door
2. Above a machine to restart heartbeat
3. At a emergency door
4. At the door of the guardian, keeping the first aid kit




A B C D

05.06.02: This sign means:

a) Grab electrical cable
b) Break glass to open
c) Hold railing tight

5.7 Properties of materials

Before you start, you should read the chapter 05.01 Fire theory.

At the end of this block, you:

- Understand fire behaviour and stability of materials.
- Recognize risks.
- Recognize different materials.

A performance environment is an environment with a high risk for fire. A lot of the materials used in sets, legs and borders, etc. increase the risk for fire and the spreading of fire. Therefore, it is important to ensure that all materials used have specific qualities concerning their behaviour in case of fire.

Two aspects have to be looked at:

- **Burning behaviour**, or how the material will respond to an ignition source. How will the material behave when on fire and what are the secondary risks like burning debris. For example, will the material continue to burn and produce burning debris flying around or will it drip of hot drops.
- **Stability**, or how much will the structural strength of the material be influenced by a fire. For example, will the suspension of a set or a riser floor hold in case of fire.

It is important to look at the commonly used materials on stages and **the way they are used** to identify the proper risks. These can be different from the use for decoration in buildings for example.

Burning behaviour

The fire behaviour of a material describes what happens if it is brought in contact with fire or heat. The first thing we want to know is if a material will **burn or singe** in contact with an ignition source. We also want to know if the material **continues burning** if the ignition source is removed and how fast it burns. We want to know the propagation of the flame, in other words how fast the fire will spread. Clearly, the ideal is that the material doesn't burn at all and second best is that it is **self-extinguishing**.

A second thing we want to know is if a flame will affect the structure of the material, if it will deteriorate. And even more importantly, if the material will produce **flaming debris or drips**, which creates the risk of setting fire to other materials. Of course we want to have a material that doesn't deteriorate and doesn't spread any flaming debris. This avoids spreading a fire.

This information will help us to assess the **risk of spreading** a fire. The information is given in a standardised way, using norms describing the fire behaviour. This way, we can be sure that we know how materials will behave wherever they come from.

Fireproofing

Fireproofing can be established by using specific materials. Materials that are not fireproof by themselves can be **coated or impregnated** with specific products. This is a highly specialised job and is mostly done by expert companies. Some materials are nearly impossible to fireproof, mainly because they are not porous enough to absorb the product, or coatings do not attach well to it. This is the case for a lot of plastics.

Fig. 5.7.a Stopwatch

A supplier or a fireproofing company will deliver a **certificate** stating the level of fireproofing that is established. This helps us to monitor if all materials on stage are OK. If the certificate is expired or non-existent, you need to warn a responsible person.

Impregnating products and coatings have a **limited lifespan** and need to be "refreshed" on a regular basis.

Stability

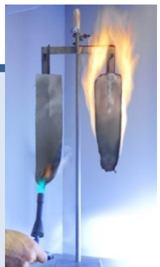
If a fire occurs on stage, we want to avoid that **suspended equipment** falls down, or that the floor of (temporary) risers will collapse. Therefore the materials used in these constructions need a certain resistance to fire. They need to stay stable for a certain time to ensure fire workers can do their job and staff can evacuate. Examples of critical materials are steels and slings that suspend trusses and structural or floor elements.

The stability is expressed in "**fire resistance**" (RF). This is expressed in time, namely how long an element will resist fire. A fire resistance of 30 min, 1 h or 2 h is most common.

Test methods

A simple test to get an idea of fire properties of a material is to take a small sample and light it. Hold it vertically (with pliers or so, not with your fingers) and light it in a safe place where extinguishing is easy (like above a bucket of water or sand). Take away the ignition flame. You can then see if and how quickly burning stops, what amount and what type of smoke is produced, and if any melting drops can spread the fire. This gives an indication, but is of course no guarantee.

To be sure of the properties, the material needs to be tested under standardised circumstances. This is done in a fire lab. The material is fixed in a "fire box" and lit by a standardised flame during a specific amount of time with a predefined draft of air. The whole procedure is executed according the standard in mind and the results are documented.



Pic. 5.7.2 Burn test

Pic. 5.7.1 Fire box

Standards

The European standard EN 13773 distinguishes 5 classes of fire behaviour. The standard is not widely accepted in the performing arts and entertainment. In most cases the national standards are used. They are relatively well accepted between countries.

The most common standards are listed below:

Code	Standard	Country
NFP-M1	NFP 92-503/M1	France
DIN-B1	DIN 4102/B1	Germany
NEN	NEN 6941/6065/6066	The Netherlands
BS-2B	BS 5867 part 2B	United Kingdom

Less evident materials

We also should look into fire risks with materials used in a way they are not meant for or with unexpected heat sources. For example filters in the focal point of a beam or tape applied on a spotlight.

Pic. 5.7.3 Burned filter

What you need to remember

- Burning behaviour describes how a material responds to an ignition source, how it behaves when on fire and what the secondary risks are, like burning debris.
- Stability describes how much the structural strength of the material will be influenced by a fire.
- The stability is expressed in “fire resistance” (RF). This is expressed in time, namely how long an element will resist fire.
- Fireproofing can be established by using specific materials. Materials that are not fireproof by themselves can be coated or

Terms and definitions

- burning behaviour
- stability
- fireproofing
- impregnating
- fire resistance

Rehearsal questions

05.07.01 True/False

Fire proofed materials do not burn under any circumstances.

05.07.02 True/False

A door with an RF of 1h will burn for a full hour.

5.8 Safety distances

At the end of this block, you:

- Understand the principles of safety distances.

One of the primary measures to prevent fire is to **keep ignition sources away** from combustible materials. The safety distance is the minimum distance that guarantees that an ignition source doesn't ignite or damage a material, object or individual.

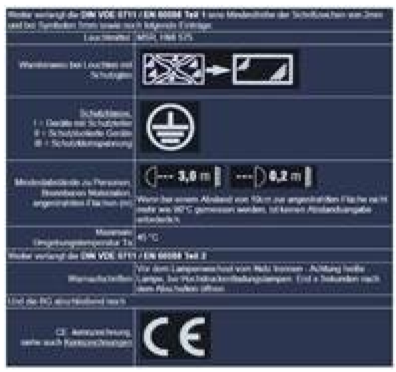
Ignition sources are avoided in a performance or event environment, but in some cases they are essential to the activity on stage. Some examples:

- Open flames from candles, tea lights, … on stage
- Cigarettes on stage
- Explosive devices for pyrotechnics or flame effects
- Heat from spotlights, not only in the focal point of the beam, but also the heat radiating from the body
- Laser beams
- …

Fig. 5.8.a Dancer

If **people** come too close to an ignition source, they can get burns or their clothes or wigs can set on fire. In normal circumstances, there is no need for costumes to be made fire resistant. But in case of an increased fire risk, safety distances should be defined. You should take care, especially for high flammable materials like nylon. (A nylon tutu is made from highly flammable material, with a lot of surrounding oxygen.)

Objects and materials like theatre curtains can catch on fire, or suffer damage to the surface even if they are fire retardant. A safety distance should be defined and maintained here too. Objects or materials that are within the safety distance need to get extra protection in case coming too close is unavoidable. This is especially true for floors.



Pic. 5.8.1 Safety label, showing the safety distances

Safety distances can be described in different ways, sometimes multiple safety distances are given for one source. Fireworks or flame projectors will have a different safety distance in the horizontal and vertical direction. Spotlights will have a different safety distance on the sides and in the beam.

The safety distance depends on the energy of the **ignition source** and the expected **fire resistance** of the surrounding materials. For pyrotechnics the distance also depends on how far **burning material** can be spread. Safety distances can be prescribed by the manufacturer (Fireworks, flame projectors, spotlights, ...) or defined by a risk assessment.

For specific applications, giving a safety distance is not enough. Some effects are mobile (smoking on stage, mobile pyrotechnics, ...) or the effect is not limited to a specific distance from the equipment (laser). In this case, **safety areas** are defined, where there need to be extra protection measures taken.

Based on the above, it will be clear that maintaining safety distances **during set-up and performance** is one of the most important measures to improve fire safety.

What you need to remember

- The safety distance is the minimum distance that guarantees that an ignition source doesn't ignite or damage a material, object or individual.
- The safety distance depends on the energy of the ignition source and the expected fire resistance of the surrounding materials.

Terms and definitions

- safety distance
- highly flammable materials
- ignition source
- safety area

Rehearsal questions

05.08.01 Safety distances depend on

a) the object at risk.
b) the ignition source.
c) both the object and the source.

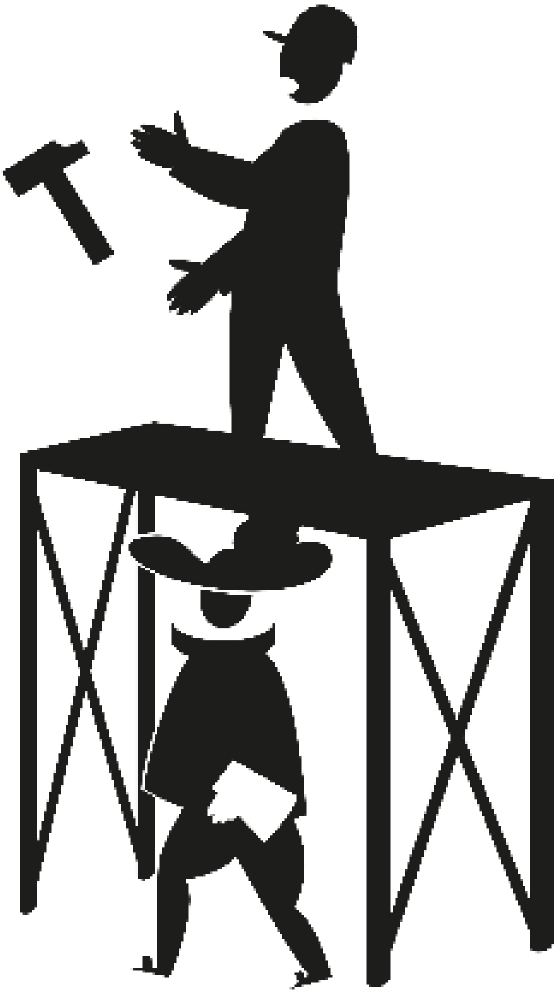
05.08.02 True/False

The safety distance is the same in every direction.

05.08.03 When we use a laser

a) we need to define a safety distance.
b) we need to define a safety area.
c) we need to define a maximum exposure time.

6 Work safely at height



To Work safely at height, you must:

Take necessary precautions while working at height, on ladders, mobile scaffolding, fixed working bridges, single person lifts etc. in order to prevent falling or endangering people working under these structures.

This means you master following skills:

- Selects and uses the appropriate equipment to go to the high working post
- Identifies / spots environmental influences and changes that affect the safe use (weather, rake, floor stability,...)
- Ensures underlying work area is free
- Mounts and uses the equipment according to the safety regulations and instructions
- Visually inspects the equipment
- Applies the appropriate collective protection
- Uses the appropriate personal protection equipment
- Ensures no objects can fall during activity
- Secures small tools and equipment
- Closes off underlying areas
- Communicates with colleagues while working at height

You master following knowledge:

- Ladders
- Mobile tower scaffold
- Mobile elevating work platform
- (Fall protection)

You have following attitudes:

- Safety awareness
- Proactive

Working at height includes all situations where there is a **substantial difference in height** between the floor you are working on and the environment. This includes all situations in the vicinity of a risk for falling or **where people are working underneath you** (working bridges, grid, etc.). Falls from height and falling objects are some of the major causes of fatal work accidents. This is why working safely at height is crucial for a safe working environment.

We exclude activities on mobile platforms or involving rope access work (climbing). These are specialist competences. We focus on non-specialist equipment relevant for daily theatre and event practice only.

Only when needed

There is a large consensus about the fact that working at height should only be done **if there is no reasonable other way** to get the job done and if it is done **for a short time** only. So where possible, we will avoid working at height. The main question is not if a specific request should be carried out or not, but if the work can be organised in a different way to avoid working at height, some examples:

- Can a spotlight be lowered to fix it?
- Can sets be mounted on the floor before they are hung?

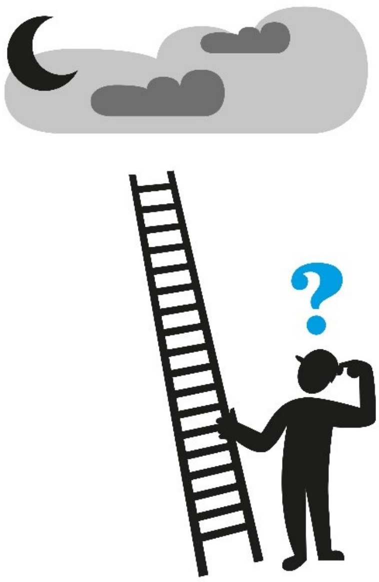


Fig. 5.8.a a ladder to the moon

Risk assessment

Choosing the appropriate method to work at height is always based on a **(risk) assessment of the task**. Often this is a last minute risk assessment. Questions that need to be answered are:

- What height needs to be reached?
- How long will the job take?
- How (easy) can the object be reached?
- Does the person working at height need to use a lot of force?
- Does the person working at height need to use tools?
- Does the person working at height need to reach out?
- Does the work at height involve electricity?
- Can one person do the job?
- Are people needed below the work surface?
- How often does this work occur?
- How much space is available on the floor?
- Does the person need to transfer to or step on another floor or platform?
- Are there attachment points for fall protection available?
- How can we evacuate a person at height?

Based on these answers, a way of working and **the most suitable tools** are chosen. In this process we always choose the safest possible way. For example: a ladder will be more dangerous than scaffolding, scaffolding will be more dangerous than a working platform and a working platform will be more dangerous than working on the ground.

All the elements above are the input for a risk assessment, that has to be done for each situation. This risk assessment leads you to the safest choice.

Medical fitness

Medical fitness is crucial if you work at height. Most countries have obligatory health assessments on a regular base for their workers. This health assessment is based on the risks of the specific tasks or the specific environment the worker will be active in. But this is only a snapshot covering your general health situation. Everyone gets ill at a certain moment and it is quite possible this makes you unfit to work at height. You should not work at height:

- **If you don't feel well**, suffer from dizziness, feel like you will faint, …
- **If you are under the influence** of alcohol, drugs, …
- If you are **extremely tired or stressed**.
- If you are under the influence of **medication**, even if you feel fine, you should check the information leaflet that accompanies the medicine. If you are not allowed to drive, or indications of dizziness or fainting are given, you are not allowed to work at height.
- If you suffer from **Acrophobia or fear of heights**. This is an extreme form of fear of falling, resulting in panic attacks in high places and you becoming too agitated to get down safely. This is not to be confused with the natural fear when exposed to heights, which is a natural protection against risky or irresponsible behaviour. You should not work at height if you suffer from acrophobia, because you would endanger not only yourself, but also colleagues that need to rescue you.

Fig. 5.8.b feeling dizzy

Training and instruction

Just as for any other job, you need to have had instructions and training before you work at height. Depending on the country you work in, this can mean you need a certificate or a document proving internal training. The training ensures you are able to:

- **Set up** the equipment properly
- Perform pre-use **checks**
- **Use** the equipment according to instructions

- **Know** what the equipment is meant for (and not use it for anything else)
- Use the appropriate **personal safety equipment**
- **Protect** the people around you

Despite training, when you are on a new, unknown location, you need to get instructions about the way of working at height in that specific location. Sometimes habits, demands or rules can be stricter then the law requires.

Use personal protection

The use of personal protection equipment depends on the specific risks in the concrete work situation. Your employer or the person responsible for safety will provide you with instructions for your specific task based on a risk assessment. The most commonly occurring personal protection for situations at height will be:

- A **hard hat**, to protect you against bumps when going up
- **Restraining or fall protection** to keep you from falling
- **Slip resistant shoes**

Plan for the worst

There is always a risk that you will fall, get injured at height or need to be rescued. It is essential that these emergencies are **planned and trained** in advance. In some cases, for example someone unconscious hanging in a fall arrest harness, you only have 10 minutes to retrieve them, so there is no time for improvisation. This also means there always needs to be a second trained person on site.

Just like any other work place, a high working spot needs to have **emergency exits or escape ways** in case of fire. If you work on a high place, you probably need to evacuate even faster, the heat of the fire will affect you earlier, because heat rises. For specific situations, like follow spot operators in bridges, ropes with emergency descenders will be in place. You need to be trained to use them.

Surfaces below

When you are working at height, the risk is not only for you, but also for the **people standing or working below you**. You can drop something or even fall on top of someone. These risks need to be tackled from both points of view:

From the point of view of the people below

- Clear the area of unauthorised and unneeded people.
- Close off the area with a rope or fences.
- Ensure a clear view on the area.
- Ensure proper communication with the people below.
- Ensure PPEs are worn by people needed below.
- Ask someone to supervise the area.
- Warn that someone is working at height at the entrances.
- In a public space, you need a guide to control the public.

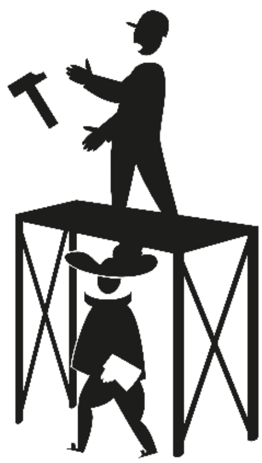


Fig. 5.8-c The Head

From your point of view

- Empty your pockets or close them to avoid stuff falling out.
- Carry only the necessary tools.
- Secure tools with a wristband or lanyard.
- Use a pulley to lift equipment you need.
- Place toe boards where possible.
- Wear fall protection.

Areas with collective protection

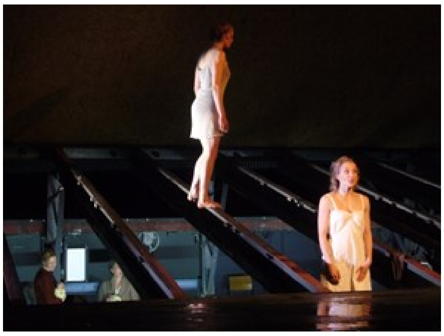
Where possible, we will use collective protection to avoid falling from heights. Working bridges have railings, open elevators or orchestra pits during build up or rehearsals will be fenced off. In theory, this collective protection **should stop you (and everybody else) from falling**. But still some risks remain. If you need to **reach out** over the railing or need to work high above the railing, you can drop tools, equipment,… So even in these situations, a risk assessment has to be made and appropriate measures need to be taken.

Areas with no collective protection

In exceptional situations it can be impossible to provide collective protection. An example could be work during setup where fences have not (yet) been put in place. In this case we will need to rely on **individual protection**, like fall arrest or restraint harnesses. This situation has to be kept as short as possible. Once possible, the collective protection needs to be put in place again.

But even this is not always possible. Think of the orchestra pit, an open elevator or a performer on a high platform during performance. The performer needs to be able to move, to sing,… and the protection can't be visible. Putting up a fence would be incompatible with the artistic goals of the performance. In these cases more **specific measures** need to be taken, relying on warning and training the people involved. Examples of measures could be:

- Improving visibility
- Lit edges
- Keeping a safety distance from the edge
- Not walking backwards
- Ensuring a view on the surface you walk on
- Warning signs



Pic. 5.8.1 no collective protection

Inspection of the work area and environment

Whenever you work at height, you need to check if the environment you are working in doesn't cause any risks. Typical things to look for are:

- Clean floor, no tripping hazard
- Bumps and holes
- Unstable or slippery surface or floor

- Floor strength
- Obstacles at height
- Wind and weather
- Unauthorised persons

Use of ladders

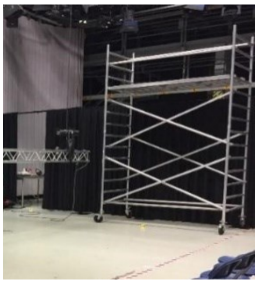
Pic. 5.8.2 ladders

In the first place, ladders are meant for accessing other levels and platforms. They can only be used for work that is **occasional and non-repetitive**, that doesn't imply putting **large forces** when handling heavy loads, that is feasible with **one hand** and within **arm's length reach** and where no safer means of access is available and practical.

Some basic rules that will make your work safer:

- Do not put a ladder near the edge of an opening in the floor.
- Do not put ladders on risers, bridges or scaffolding.
- Do not put a ladder in front of a door, if necessary, lock the door and put up warning signs.
- Ladders are not designed to be used horizontally or upside down.
- Ladders must rest on their side rails, the rungs are not made for support.
- Check hinges, spreader bars, and locks before climbing.
- Check the angle of the ladder before climbing.
- A ladder should be one meter higher than the spot you will be working on.
- Do not allow anyone under the ladder during climbing or working.
- Stay with both feet on the ladder and keep your belt buckle in between the rails, don't reach out further than an arm's length.

Use of mobile scaffolding



Pic. 5.8.3 mobile scaffolding

To use a mobile tower scaffold, you need to be trained and informed. The **height-to-width ratio** of a mobile tower scaffold should not be greater than 3 to 1. Avoid working on a unguarded platform, also when building, and secure all parts immediately. Always **climb a tower on the inside**, never sit or stand on the railings, never use any means to increase working height and never reach out further than arm's length. Ensure the route is clear, free of obstacles and free of holes or bumps before you move the tower. Never move the scaffold by **pulling it forward** when standing on top of it! Always use the **brakes** of the castor wheels.

Use of a mobile elevating work platform

Pic. 5.8.4 MEWP

To use a mobile elevating work platform, you need to be trained and informed not only in general, but also to the **specific machine** and the **situation** you work in. Always check for obstacles above you when operating. Stay with **both feet** on the platform and **don't overreach**, never **sit or stand on the railings**. Keep the cage clean and clear of obstacles. Use a hard hat and fall restraint, **never move when at height** or disarm the **safety features**. Always use outriggers. Prepare yourself for **emergency**.

Terms and definitions

- working at height
- mobile platforms
- rope access
- medical fitness
- acrophobia
- internal training
- pre-use check
- risk assessment
- surfaces below
- unauthorised person
- safety distance
- scaffolding
- collective protection
- mobile elevating work platform

6.1 Ladders

At the end of this block, you:

- Know the different types of ladders and their use.
- Understand how to set up ladders and work on them.

A ladder is a vertical or inclined set of rungs or steps, connected to vertical members called stiles. There is a large variety of ladders, stepladders for smaller work, extendable ladders to reach high surfaces, A and Y ladders that stand autonomously and fixed ladders like the ones found in a stage house to connect the different levels and bridges. You can even find A-ladders with wheels. We do not discuss rope ladders in this chapter, as they are part of specialised skills.

Choosing

In the first place, ladders are meant for accessing other levels and platforms. They can only be used for work:

- that is **occasional** and **non-repetitive**.
- that doesn't imply putting **large forces** when handling heavy loads.
- that is **feasible** with one hand and within arm's length reach.
- where **no safer means** of access is available and practical.

(Examples are focussing a spotlight, plugging a cable, etc.)

Where possible, it is preferable to use scaffolding or an elevated work platform.

Carrying and transporting

When carrying ladders, some basic rules apply:

- Carry a ladder on your shoulder with the front part up. This avoids unwanted contact with other people.
- Pay attention to obstacles at height (fixtures, cables, etc.).
- Watch out at doors and corners and warn people you are coming.
- Heavy ladders should be transported with two people, one on each end.
- If you carry a ladder standing up, hold a low rung to lift with a stretched arm and a high rung to support the ladder. If you get out of balance, put the feet of the ladder on the ground.

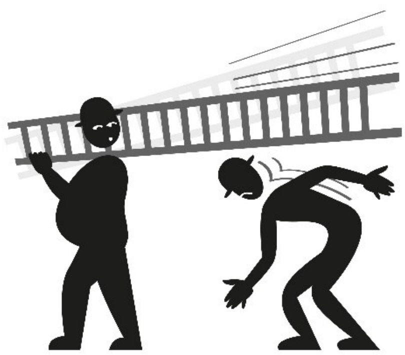


Fig. 6.1.a Laurel and Hardy

For short distances, a ladder can be carried vertically. Take care for obstacles at height and keep the feet of the ladder close to the ground, so you can put it down if it gets unbalanced.

If you transport a ladder with a vehicle

- Be sure it is well secured.
- Check the turning circle.
- Check warning signs and other signalisation.

Checking

Before you use a ladder, you should carry out a **visual check**. If you find any defects on a ladder, it should be taken **out of service**. The ladder should be stored in a separate location from ladders that are in function, to avoid mistakes. The ladder should be clearly tagged with "out of order" or similar text. You also need to inform the responsible person about this.

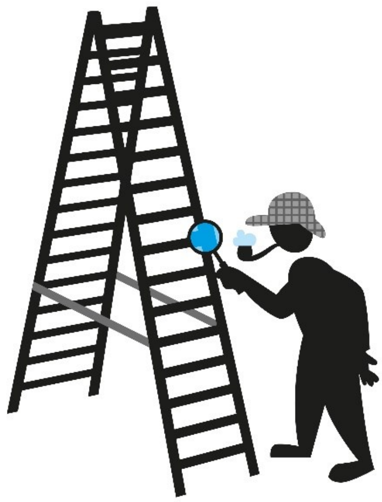


Fig. 6.1.b inspection

The responsible person will decide to scrap the ladder or let repairs be carried out by the manufacturer. Repairing ladders is a specialised task. You should not try to repair them yourself.

A visual check includes:

- structural rigidity
- excessive wear
- corrosion
- joints between fixed parts should be tight, secure and free of damage
- movable parts should operate freely without binding or excessive play
- end caps should be in place
- grease, oil or other substances that make the steps slippery
- safety, periodic check, use and maintenance indications
- Non-skid feet should be checked for:
    - attachment
    - wear
    - imbedded material
    - proper pivot action on swivel feet.
- Multiple parts ladders should be checked for:
    - play tolerance between moving parts.
- Aluminium ladders should be checked for:
    - dents, bends and deformation in side rails, steps, and rungs.

- Wooden ladders should be checked for:
    - cracks, splitting, and rot
    - compression failures
    - not painted, or covered with a transparent finish only.
- Extension ladders should be checked for:
    - gravity-action ladder locks operating freely
    - deteriorated, frayed or worn ropes.
- Double or "A" ladders should be checked for:
    - damage or deformation of hinge point
    - damage on spreader bars, chains or ropes.
- Platform ladders should be checked for:
    - proper closure of the platform

Setting up

Before you put up a ladder, you have to **check the environment**:

- Keep the zone around the ladder free.
- Do not put a ladder near the edge of an opening in the floor.
- Do not put ladders on risers, bridges or scaffolding.
- Do not put a ladder in front of a door, if necessary, lock the door and put up warning signs.
- Ensure your ladder is not blocking emergency exits or routes.
- Do not leave a ladder unattended.
- In case you are working in public domain or a place where vehicles can move, put traffic warning signs in place or make use of a traffic controller.
- Avoid places with (touchable) electrical installations or overhead power lines.
- When you work in open air, take weather conditions into account, high winds (6 Beaufort = 45 km/h) can cause your ladder to topple.

Fig. 6.1.c in front of door

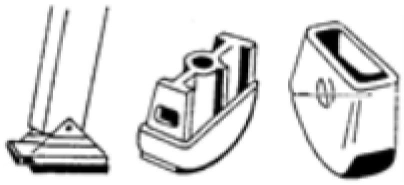
Ladders are designed for a **specific purpose**. If you use them in another way or for another purpose, there is no guarantee that the ladder will hold.

- Ladders are not constructed to be used **horizontally or upside down**.
- Ladders are not made to be **tied or bolted together**.
- Ladders are not designed to step from one to another. If you use several ladders to reach a work place, there needs to be a **platform** between the ladders.

Base / support

The base of a ladder is like a **fundament**, if the base is not supported properly, the stability and the strength of the ladder are in danger. Some basic rules apply here:

- The base should not slip away, this can possibly be done by adapted non-slip feet, other protection, or anchoring the feet.
- Ladders must rest on their side rails, the rungs are not made for support.
- Avoid putting ladders on a slope or putting the feet on different levels.
- Do not put ladders on flight cases, wagons, working platforms, or any other object.
- The underground must be stable and horizontal.
- The rungs should be horizontal.
- Put extra support on soft surfaces if needed.
- Use stabilisers if needed.



Pic. 6.1.1 non-slip feet

Stepladder / platform ladder

A stepladder is a light **freestanding** ladder with **flat steps** and a hinged frame. A platform ladder is a similar tool, but has a **work platform** on top, with a handrail. Both can be used to work on, in contrast to other ladders.

If you set up a step ladder:

- Make sure the ladder is opened completely.
- Make sure the platform is locked.
- Make sure the spreaders are horizontal.

Pic. 6.1.2 platform ladder and stepladder

Double or "A" ladders

A double ladder is a set of ladders that are connected with a **hinge**. The feet of the ladders are set apart, limited by a **spreader bar or a rope**. This ensures a stable construction to climb on, in the shape of an A frame.

Pic. 6.1.3 A ladder

The easiest and safest way to set up a double ladder is to

- put the ladder straight up,
- take the smallest part out,
- lower this part in the hooks of the hinge points,
- walk away with the smallest part until completely open,
- check the hinges,
- ensure the spreader bars, chains or ropes are tensioned.

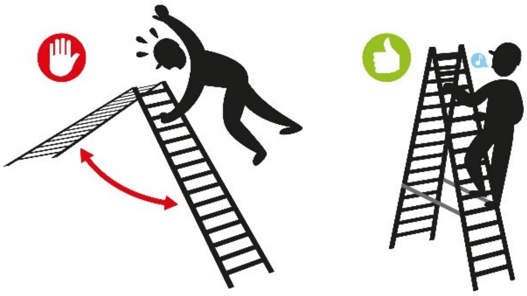


Fig. 6.1.d spreader bars

Combination or "Y" ladder

Pic. 6.1.4 Y ladder

A combination or Y ladder is a double or A ladder that has an extra part that can be **extended**.

- Set up as a double ladder.
- Ensure the ladder is standing properly.
- Unlock the rung locks.
- Slide the telescopic section upwards.
- Keep the telescopic part close to the ladder.
- If needed, walk up the ladder.

Extension ladders

Pic. 6.1.5 extension ladder

An extension ladder is a fixed ladder divided into two or more lengths for more convenient transport and storage; the lengths can be slid together or slid apart to **expand the length** of the ladder.

- Walk up the ladder.
- Unlock the rung locks.
- Extend the telescopic section.
- Keep an overlap of at least 1m (check manual).
- Check the rung locks.

Walking up a ladder

To bring larger ladders like A ladders or extension ladders in a vertical position, we need to walk them up, the procedure for this is as follows:

- Put the ladder to a wall or ask someone to put his feet against the bottom of the ladder.
- Walk the ladder up, one rung at a time.
- If the ladder is to heavy, ask for help.

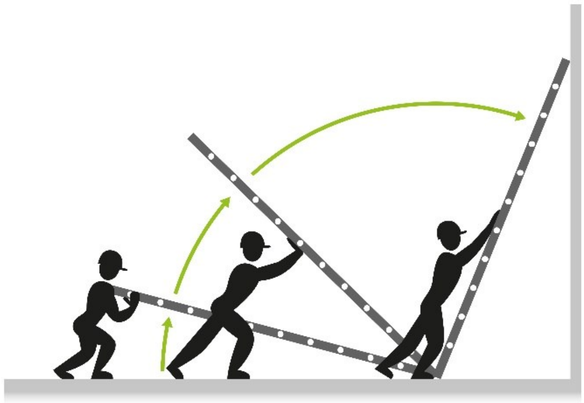


Fig. 6.1.e walking up a ladder

Top

- If you put a ladder against a wall, both side rails should be supported by the wall. If the surface is not even, special tools need to be used.
- A ladder should be one meter higher than the spot you will be working on.
- When the ladder is used to access a platform, it should stick out at least one meter, so the user has support to cross from one to the other.
- Be sure the surface is immobile and strong enough. Never put a ladder against a scaffolding tower, a set or another unstable object.
- If a ladder is very high (25 steps), it should be secured / tied off at the top.

Fig. 6.1.f over the top

Angle

Straight or extension ladders should be erected at such an angle that the horizontal distance between the top support and the base is not less than one-quarter or greater than one-third the vertical distance between these points (**68-75°**).

There are two easy ways to check this:

- If you put your toes on the bottom of the ladder, you should be able to touch the ladder at shoulder height.
- If you stand sideways with your ankle to the lowest spur, you should be able to touch the ladder with your elbow.

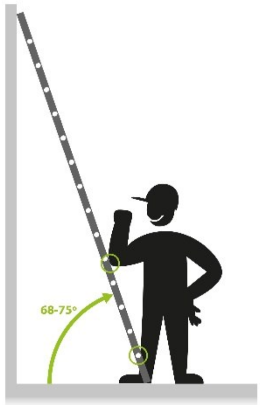


Fig. 6.1.g elbow

Fig. 6.1.h angle

If the angle is too steep, the ladder could fall over. If the angle is too slope, the ladder could slide away or bend.

Climbing

When climbing on a ladder, there are some basic rules to remember:

- Use footwear with slip resistant soles.
- Always keep 3 points of contact with ladder and handrails.
- Climb one rung at a time.
- Face the ladder when ascending or descending.
- Check rung locks when you pass them (telescopic ladders).
- Check for obstacles above your head to avoid bumping your head.

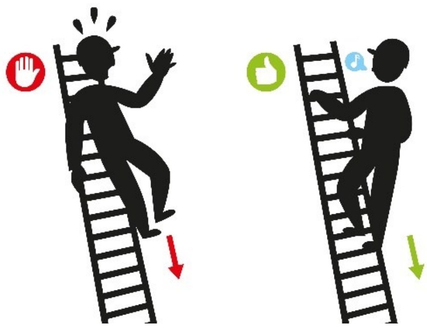


Fig. 6.1.i climbing

- Do not allow anyone under the ladder during climbing or working.
- Don't carry equipment or material in your hands, use a bag, a tool belt or hoist it up.
- Ask someone to secure the ladder when the ground surface is slippery.
- Always hold on to the ladder rails when entering / leaving a work platform.
- Use a fall-arrest system on long (permanent) ladders.

Working

When working on a ladder, there are some basic rules to keep you safe for all types of ladders:

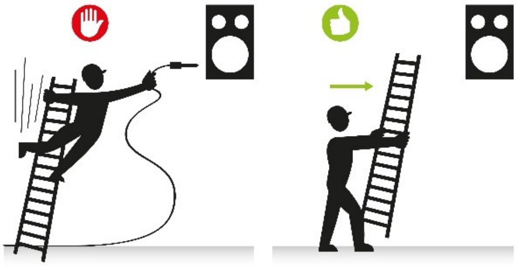


Fig. 6.1.j arm's length

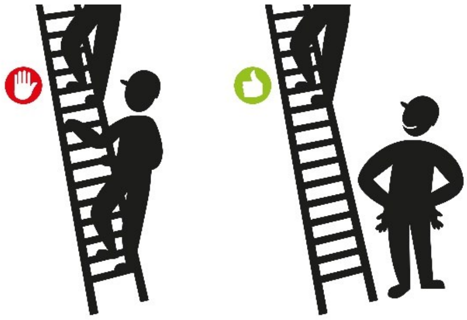


Fig. 6.1.k two persons

- Stay with both feet on the ladder and keep your belt buckle in between the rails (Your gravity point will stay within the ground surface.)
- Don't reach out further than an arm's length.
- Move the ladder instead of leaning out too far.
- Do not apply force on the sides of the ladder.
- Don't use machines that create a large torque (in work or when blocking).
- Never work on one ladder with two persons.
- Never stand higher than the fourth highest rung.
- Never straddle the space between a ladder and another object.
- Always hold the ladder with one hand during activities (and two feet on the rungs).
- Never try to move the ladder while you are on it (by jumping "walking", etc.).
- Keep tools in a closed bag or tool belt.
- Ensure no one is standing under your workplace.

Fig. 6.1.l straddle

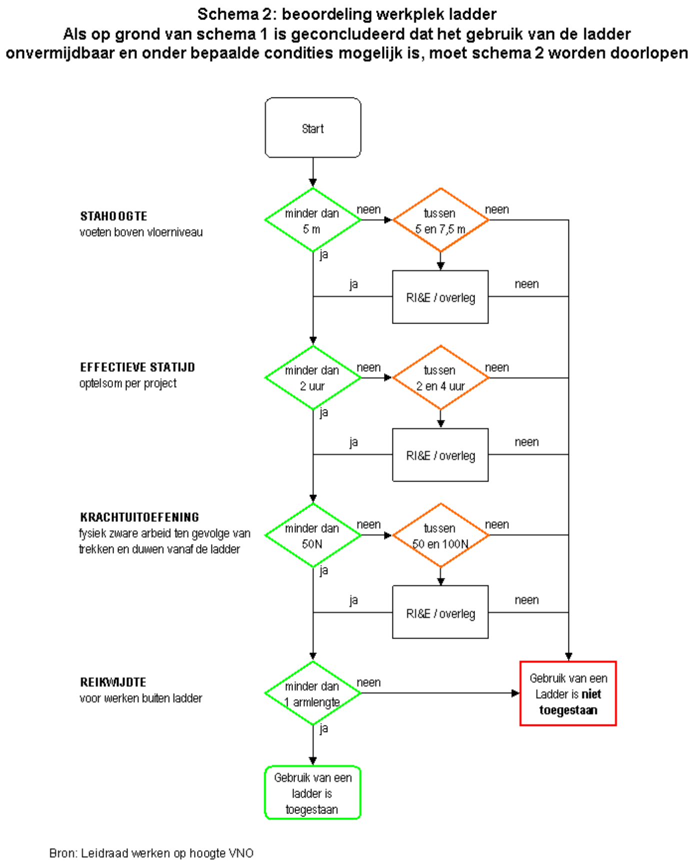
Storage and maintenance

Before storage, ladders need to be **cleaned and checked**. If needed, hinge points should be lubricated. Ladders should be **stored** in a safe place that ensures protection against damage, weather influences, corrosive products and unauthorised use. Make sure they cannot **fall over**. Wooden ladders should be stored in a well-ventilated place.

Ideally, ladders are stored **vertically** to avoid deformation or bending. A problem when a ladder is stored horizontally (on its side), is that it easily hits the floor too hard when put down, which often leads to damage to the hinges. Also, in that position the different parts of the ladder easily move out of their alignment axis, which often causes deformation. Storing a ladder by laying it flat on the floor may be better for the ladder itself, but takes a lot of space and can produce a risk of tripping over it. When ladders are stored hanging, they should be supported properly. Never hang things on a stored ladder.

Decision scheme in the Netherlands

In some countries, a decision scheme is used to decide in which cases a ladder can be used. Below is an example from the Netherlands. The first step considers the height your feet are on. If this is less than 5m, there is no problem, between 5m and 7.5m a risk assessment has to be made. Above 7.5m the use is unacceptable. Next, we look at the time you are effectively standing on the ladder. Up until 2h, there is no problem, between 2 and 4h, you need a risk assessment. Longer than 4h is unacceptable. Next, the force you will apply when working is considered. If this is 50N, again there is no problem. Between 50N and 100N, you need a risk assessment and above 100N is unacceptable. The last step checks if the reach within which you need to carry out the work is not more than 1 arm's length.



What you need to remember

Ladders are in the first place meant for accessing other levels and platforms. They can only be used for work:

- that is occasional and non-repetitive.
- that doesn't imply putting large forces of handling heavy loads.
- that is feasible with one hand and within arm's length reach.
- where no safer means of access is available and practical.

Some basic rules will make your work safer:

- Do not put a ladder near the edge of an opening in the floor.
- Do not put ladders on risers, bridges or scaffolding.
- Do not put a ladder in front of a door, if necessary lock the door and put up warning signs.
- Ladders are not constructed to be used horizontally or upside down.
- Ladders must rest on their side rails, the rungs are not made for support.
- Check hinges, spreader bars, and locks before climbing.
- Check the angle of the ladder before climbing.
- A ladder should be one meter higher than the spot you will be working on.
- Do not allow anyone under the ladder during climbing or working.
- Stay with both feet on the ladder and keep your belt buckle in between the rails, don't reach out further than an arm's length.

The different types of ladders:

- Stepladder
- Platform ladder
- Double or A ladders
- Extension ladders
- Combination or Y ladders

Terms and definitions

- ladder
- platform ladder
- stepladder
- extendable ladder
- A ladder or double ladder
- Y ladder
- fixed ladder
- occasional
- non-repetitive
- rung
- stile
- base
- stabiliser
- spreader bar
- rung lock
- structural rigidity
- excessive wear
- corrosion
- joints
- movable parts
- end caps

Rehearsal questions

06.01.01 A ladder is the best choice if

a) I can do the job with one hand.
b) I have to put a large force.
c) Never

06.01.02 A visual check has to be done

a) Every year.
b) Every month.
c) Every time you use a ladder.

06.01.03 An aluminium ladder should be decommissioned when

a) there is paint on the ladder.
b) there are deformations on the side rails.
c) it weighs more than 5kg.

06.01.04 To transport an extension ladder to another building, you can best

a) carry the ladder vertically.
b) carry the ladder horizontally.
c) use the wheels at the top of the ladder.

06.01.05 A ladder that stands independently and can be extended is an

a) step ladder.
b) A ladder.
c) Y ladder.
d) extension ladder.

06.01.06 True/False

- When setting up an A ladder, the opening angle should be as sharp as possible.

06.01.07 When the ladder is used to access a platform, the top

a) should not stick out above the platform.
b) should stick out at least a meter.
c) should be at exactly the same height as the platform.

06.01.08 The angle of a straight ladder against a wall should be

a) 45-55°
b) 70-75°
c) 85-95°

06.01.09 True/False

- The best way to descent a ladder is with your back to the rungs.

06.01.10 Match

1. Step ladder
2. A ladder
3. Y ladder
4. Extension ladder


A


B


C


D

06.01.11 You should keep your belt buckle in between the rails of a ladder because

a) the buckle will hold you when you fall.
b) your gravity point will stay within the ground surface.
c) otherwise you could get your belt tangled with the rails.

6.2 Mobile tower scaffold

At the end of this block, you:

- Know what the parts of a mobile tower scaffold are.
- Understand how to check, assemble, access and move a mobile tower scaffold.
- Know what points you need to pay attention to when working on a mobile tower scaffold.

A mobile tower scaffold is used on a lot of stages and events to work at height. You can find it in many different types and sizes. Tower scaffolds are a specific form of **scaffolding**. Usually they consist of interchangeable frames, connected with braces and platforms. Most tower systems are made in aluminium or fibreglass. A tower scaffold on castor wheels is called a **mobile tower scaffold**. This type of scaffold is compact to store and doesn't need tools to be set up. It is best suited for work on smooth floors and is typically used inside buildings.

Mobile tower scaffolds provide a stable and spacious working environment for more than one person. They are very useful for work that has to be carried out in **different places, but at the same height**, and where you need **both hands**, like hanging soft goods or focussing lights.

In this chapter, we limit ourselves to mobile tower scaffolds, because they are best suited for short-duration work at multiple locations. Therefore they are widely used in the event and theatre sector.

Parts

A mobile tower scaffold is constructed out of standard parts. These parts are similar for each manufacturer, but this does not mean they are interchangeable. Every part has to be checked visually when you handle it. The most important parts are:

The **frames** form the base of the structure. These are modular frameworks that can be built on top of each other and are connected with hinge pens. The frames guarantee the stiffness of the construction. On the frames, the other elements are connected. The frames should be checked for wear and tear, especially at the connection points.

The **braces** are single pipes that connect the frames to each other, so that a three-dimensional structure is created. The horizontal braces have the same length as the platforms and ensure a fixed distance between frames. The vertical (diagonal) braces ensure structural stability. The braces click around the pipes of the frame. The click system has to be checked for firm attachment.

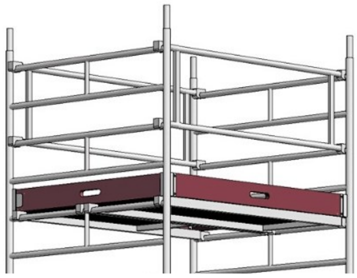
Pic. 6.2.1 click system

The **castor wheels** fit in the frames. They ensure the moving of the scaffold. In most cases the height is adjustable to be able to work on uneven terrain. The castor wheels are equipped with a brake or locking device. Often they can also be secured against rotation. This is important if the centre of the wheel is not situated perpendicular underneath the stand. The wheels have to be checked to be sure they turn swiftly and they have no damage on the surface of the wheel.

The **platforms** are the floor you will stand on to work. They have a hatch door to climb on the platform. Every platform has a weight limit that must not be exceeded. Of course the final maximum load of the scaffolding has to be calculated in relation with the total structure. The platforms should be kept clean and grease free. The click system has to be checked for firm attachment. The hatch door has to be checked for secure closure.

The **railing** secures the work area. It consists of a frame or two single pipes that are clicked at the right heights on the frames. This is the initial collective protection when working on the scaffold. The railing is not meant to stand on or to lift heavy weights from. The railing should be checked for bending, wear and the proper closure of the click system.

The **side boards** are placed on the four sides of the platform. These boards avoid objects falling or sliding off the platform.


Pic. 6.2.2 railing and side boards

Some scaffold tower types use separate **ladders** or even stairs to access the tower. In other types the frame itself is used. The ladders have to be kept clean and slip free. They have to be checked for bending, wear and the proper closure of the click system.

Outriggers are used to enlarge the floor surface of the scaffold. This ensures a higher stability. The outriggers are connected to the frames and are adjusted to touch the ground.

Assembling

Mobile tower scaffold, just as any other scaffolding, should be erected by **trained and competent** people or under the supervision of an expert. This should be done based on the instruction manual provided by manufacturer or supplier.

Secure the area when you are setting up a tower in a public area or an area where unauthorised people can walk.

The **floor** you work on should have sufficient strength to hold the weight of the tower and it should be flat and even. When it is necessary to use tower scaffolds on an inclined surface, extra measures like outriggers are needed to ensure stability.

The most difficult element in setting-up scaffold is that you have to find a safe place or position to lift the elements in place. You have to avoid working on an **unguarded platform**. One of the better options is to work from within the hatch to build the next level. Setting up a tower always requires at least two persons.

It is crucial to **secure the elements** as soon as possible in the building process. Safety pens, braces and guard rails have to be secured immediately to guarantee the stability of the tower and to avoid you holding on to an unsafe element.

Rules and instructions can vary between countries or manufacturers, but there are some rules of thumb that can be used for secure working:

- The **height-to-width ratio** is not greater than 3 to 1. This means the length of the shortest side on the floor, including the outriggers, is minimum a third of the floor height.
- All castors are equipped with **brakes.**
- Platforms **close off** the full surface between the railings.
- **Intermediate floors** are installed if the height is larger than 4 m. (Or half-floors every two meters)
- Working platforms have **guard rails and sideboards**.
- **Horizontal and vertical braces** are placed according instructions.

During setup, you check the parts you use for wear and tear. When the setup is finished, the construction should be checked **by a competent person** before it is used. This check verifies if all pens, braces, platforms and sideboards are properly installed. After this check, the mobile tower scaffold can be used.

Accessing the mobile tower scaffold

Ideally, a mobile tower scaffold has ladders or even stairs built in, but the frames can be used to access the tower if there is an acceptable rung distance. Don't use a separate ladder to access the tower under any circumstance. This would create a force on the top or the ladder could slip away if the tower is not properly stabilised.

Always climb a tower **on the inside**. Climbing on the outside can make the tower tip over. To climb you need both hands, so avoid carrying tools or equipment with you.

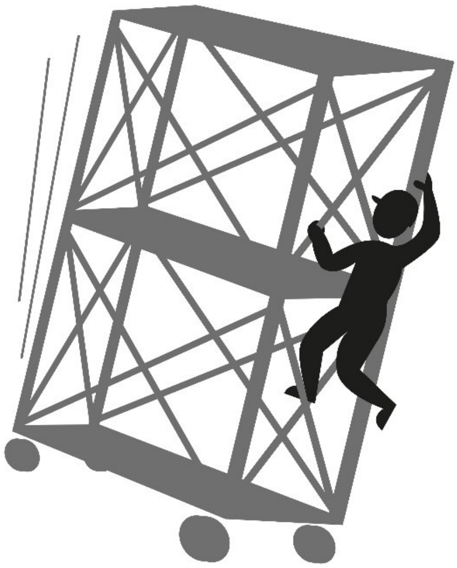


Fig. 6.2.a climbing outside

Working

Even if the working platform of a mobile tower scaffold is an area secured with guardrails and sideboards, you still work on heights. This means there is always a risk to fall or to drop objects. The amount of **tools and equipment** on the working platform should be limited to what is necessary. Using a tool lanyard is advised. Do not overload the platforms.

The guard rails only protect you when you are standing on the platform and stay within the secured area. Never use boxes, ladders, railings or other means to increase working height. Never reach out further than arm's length.

Avoid lifting equipment directly from the platform, this could cause the tower to destabilise or tip over. When possible, use a pulley on an external fixed point.

Outdoor use

When working outdoors, the weather conditions need to be taken into consideration, especially wind and rain. Rain can make the surfaces slippery. Wind can have an impact on the stability of the tower. Under no circumstance should you work on a scaffold when there is a risk for lightning. You should never hang large surfaces (sheets, screens, speakers, …) on a tower.

Pay extra attention to the ground surface when working outside. Check if the floor is stable, not skew or swampy, or has holes in it. Look around you and check for other moving objects like cherry pickers or forklifts.

Moving

Before you move a mobile tower scaffold, you need to be sure the **route is clear**, free of obstacles and free of holes or bumps. If one of the castor wheels would get stuck or slide into a hole, this would destabilise the whole tower. Especially in a performance environment, you also need to **check for overhead obstructions or electrical cables.**

You are not supposed to move the rolling scaffold while anyone is on the platform, and you have to be sure no objects can fall during the travel. **Never move the scaffold by pulling it forward when standing on top!** This pulling position will make the tower fall over.

When possible, leave the outriggers just above the floor when moving and put them back on the ground when you reached the new position. Don't forget to lock the breaks again.

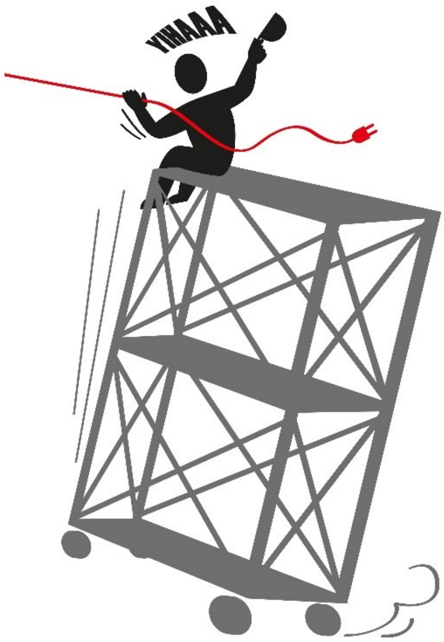


Fig. 6.2.b pulling

Checking

Besides the daily checks that you carry out yourself, mobile tower scaffolding is subject of a legally required periodical check in most countries. This inspection must be carried out by an expert or an external organisation. When this is the case, the scaffold will get a mark showing the details of the inspection.

But the first line check is done during work. While setting up, dismantling or storing the scaffold, you have every part in your hands, so these are good moments to check on wear and tear and especially dents in the aluminium.

What you need to remember

Before:

- You need to be trained and informed.

When setting up:

- Avoid working on a unguarded platform.
- Secure all parts immediately.
- The height-to-width ratio is not greater than 3 to 1.
- Always climb a tower on the inside.

When working on a mobile scaffold:

- Never sit or stand on the railings.
- Never use means to increase working height.
- Never reach out further than arm's length.

When moving a mobile scaffold:

- Ensure the route is clear, free of obstacles and free of holes or bumps.
- Never move the scaffold by pulling it forward when standing on top!
- Always use the brakes of the castor wheels.

Terms and definitions

- mobile tower scaffold
- frame
- brace
- castor wheel
- brake
- locking device
- platform
- hatch door
- railing
- side board
- outrigger
- height-to-width ratio
- overhead obstruction
- unguarded platform

Rehearsal questions

06.02.01 True/False

- The horizontal braces and the vertical (diagonal) braces have the same function.

06.02.02 True/False

- Castor wheels need a locking device against rotation in the horizontal plane if the axe of the wheel is not straight under the stand.

06.02.03 A platform needs side boards

a) on one side of the platform.
b) on both sides of the platform.
c) on four sides of the platform.

06.02.04 If you use outriggers

a) you can't work as high as without outriggers.
b) you are allowed to work higher as without outriggers.
c) you can work on the same height as without outriggers.

06.02.05 True/False

- During assembly of a mobile scaffold, you can't avoid working on an unguarded platform.

06.02.06 As a rule of thumb, the height to width ratio of a tower scaffolding has to be

a) 2 to 1.
b) 3 to 1.
c) 4 to 1.

06.02.07 The best way to access a tower scaffolding is

a) climbing on the outside.
b) using an independent ladder.
c) climbing on the inside.

06.02.08 True/False

- You always have to climb on the inside of a mobile scaffold.

06.02.09 The best way to lift equipment on a platform is

a) pull it with a pulley on an external fixed point.
b) pull it with a pulley on the railing.
c) pull it directly.

6.02.10 True/False

- The best way to protect a scaffold tower against strong winds is to cover it with a sheet.

6.02.11 True/False

- When standing on a mobile scaffold you may only pull yourself forward in the direction of the short sides.

6.3 Mobile elevating work platform

Before you start, you should read 04.05 Fall protection.

At the end of this block, you understand the risks and safety measures for class A, type 1, mobile elevating work platforms.

Mobile elevating work platforms (MEWPs) are mechanical devices used to provide temporary access for people or equipment to inaccessible areas, usually at height.

This definition covers a wide range of equipment, developed for different purposes. Most common are the telescopic elevators, the scissor type elevators and the boom type elevator. All types can be self-propelled.

We limit ourselves in this text to **class A, type 1** MEWPs (prEN 280:2009 (E)). These are **not self-propelled telescopic elevating work platforms**. With these MEWPs, the centre of the platform always stays inside the tipping lines in all platform configurations and travelling is only allowed in its transport configuration.

To use the other types of MEWPs you need more specific training and certification.

Risks

The use of MEWPs includes a lot of different risks. To minimise these risks, the operator needs to be well trained and instructed for each MEWP he/she uses. Aside from a general training in the use of MEWPs, a minimum **training** for a specific MEWP includes:

- Instructions of the manufacturer
- Local instructions and guidelines
- Instruction in the load limitations
- Instruction in and a hands-on demonstration of the proper use of all controls

To avoid that untrained people use the MEWP, the machine should never be left unattended in working mode. You need to remove the key and/or push the emergency stop.

One of the major risks using MEWPs is **entrapment**. The operator is trapped between the basket and an overhead obstacle. Additionally the operator may not be able to control the machine if trapped in a position where the control can't be reached or where the controls are hard to release. To avoid entrapment, you have to be aware of the obstacles when positioning the MEWP and you always have to look in the direction of an obstacle when moving the basket. Even without being entrapped, overhead obstacles can hurt your head. So it is advisable to wear a hard hat.

You are working on height, so there is always a risk to **fall**, even if the basket has guard rails. These railings are not made to sit or stand on. Always stay with both feet on the platform and don't overreach. Never use ladders, steps or boxes to extend the height of the platform. The railing becomes useless and the whole machine can become unstable.

Depending on the local regulations, you will need a **fall restraint system** that makes it impossible to fall out of the cage. This system should be connected to a certified attachment point in the cage when available. If no certified point is available, you need to check if the attachment point is strong enough to restraint your weight. The lanyard should be kept as short as possible and should not contain a shock absorber.

Fig. 6.3.a rope dance

You are working at height with tools, so there is always a risk for **falling objects**. Only take the tools you really need with you and position them in the cage so they can't fall. Do not take objects with you that you can't properly handle in the cage or that limit the control over the machine. Keep the floor of the cage clean and clear of obstacles. Avoid cables or ropes from getting tangled in the mechanisms of the MEWP when raising or lowering it. They can pull objects with them. Just as in every other situation where you work at height, measures must be taken to avoid injuries for people working below.

There are many causes for the machine to **tip or overturn**. The most evident one is the exposure of the machine to sideward forces. Never overreach when working, put a ladder to the cage or any other part of the MEWP, overload the cage, pull or push objects when in the cage, let loads stick out of the cage, or lift heavy objects from the cage. Another typical cause is **moving when the machine is at height**.

Pic. 6.3.1 Outrigger

Outriggers have to ensure the machine is level and stable. Outriggers that are not properly attached or where the **safety features** such as the tilt or level warning are disarmed are another cause for the machine to tip over. These features are there for a reason. They guarantee that, even if a wheel breaks or gets into a hole in the floor, the machine stays within the gravity line. It is never a good idea to override safety features or remove other measures that ensure stability.

Some MEWPs are designed to work without outriggers. They have a heavy base standing on the ground that can be pumped up to move the elevator.

The cage of a MEWP is meant to protect you. It can be opened for **entry or exit** only when it is at its lowest point. In all other situations it should be closed. Never try to enter a cage when at height, not even with a ladder or when there is a platform next to it. Never climb on the telescopic arm.

A MEWP is made to bring you to **a place to work at height**. The machine is not an elevator, a rigging structure, a jack or strut. Never use the platform hold an object, support a structure or put force on a structure.

When working **outdoors**, the surrounding situation can be different. You have to be sure that the soil is stable and can hold the weight of the machine. Spreader plates might be needed for the outriggers. There can be power lines that create a risk for electrocution. And the wind can tilt your platform and make it unstable. Under no circumstance should you work on a MEWP when there is a risk for lightning.

Emergency procedures

You have to be prepared, not only to work, but also to act **in case of an emergency**. You have to stay in the cage under all conditions. A trained second person must be available to lower the MEWP with the emergency controls in case of failure or power loss. It is important to perform a number of exercises so that even in the event of panic, the worker blindly knows how to operate the right buttons.

Checking and maintenance

Daily checks need to be done according to the instructions of the manufacturer. These checks will include wear and tear, power systems (hydraulics, batteries, etc.), the emergency features and safety elements.

In most countries, MEWPs are subject of a **legally required periodical check**. This inspection must be carried out by an expert or an external organisation. When this is the case, the scaffold will get a mark and documentation showing the details of the inspection. Maintenance of MEWPs is specialist work.

What you need to remember

Before:

- You need to be trained and informed.

When working:

- Always check for obstacles above you when operating.
- Stay with both feet on the platform and don't overreach.
- Never sit or stand on the railings.
- Use a hard hat and fall restraint.
- Keep the cage clean and clear of obstacles.
- Use outriggers.

Moving:

- Never move when at height.

Terms and definitions

- mobile elevating work platforms
- MEWP
- telescopic
- scissor type
- boom type
- self-propelled
- entrapment
- cage
- outriggers
- spreader plate
- emergency control
- periodical check

Rehearsal questions

06.03.01 The best way to secure a MEWP against untrained people is to

a) Push the emergency stop button
b) Remove the key
c) Both

06.03.02 True/False

- The railings of a basket must be constructed so you can easily climb on them.

06.03.03 If you can't reach a work spot, the best thing to do is

a) secure a box in the cage to stand on.
b) bring the cage to a higher level.
c) secure a ladder on the cage and use a lifeline while standing on it.

06.03.04 To protect you against falling out of the cage, you should use

a) a long lifeline.
b) a lifeline with a shock absorber.
c) a lifeline that can be shortened.

06.03.05 If the tilt notice makes too much noise, you should

a) disconnect it to prevent hearing damage.
b) level the outriggers till it stops.
c) send the machine to the manufacturer for maintenance.

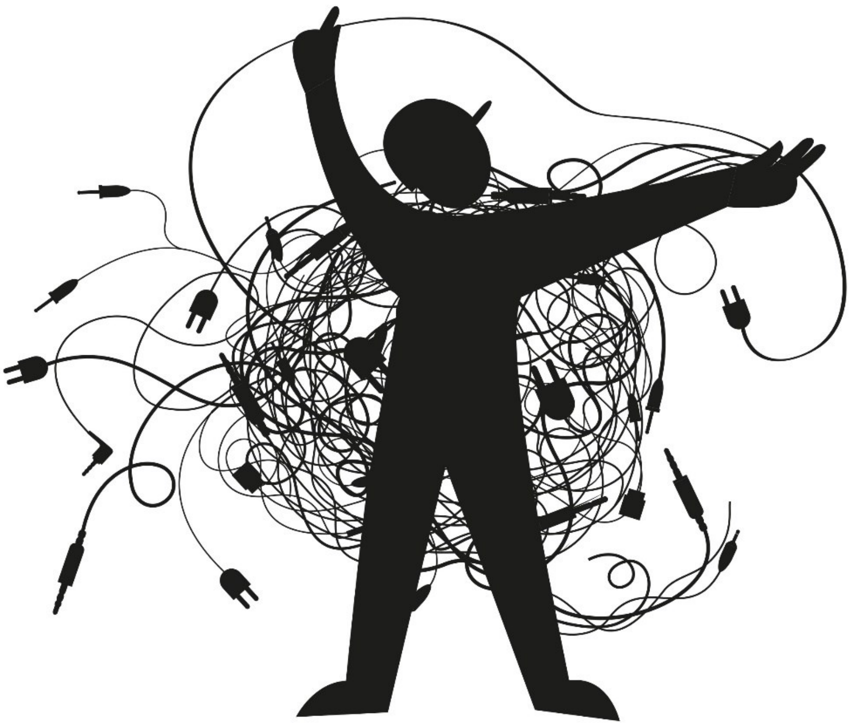
06.03.06 When you have to outreach too far, it is best to

a) ask someone to move the machine closer.
b) bend further over the railing.
c) go down and move the machine.

06.03.07 A MEWP has to be checked

a) daily.
b) monthly.
c) Yearly.

7 Work safely with mobile electrical systems under supervision



TO 7.0 WORK SAFELY WITH MOBILE ELECTRICAL SYSTEMS UNDER SUPERVISION, YOU MUST:

Take the necessary precautions while providing temporary power distribution for performance and art facility purposes under supervision.

This means you master following skills:

- Provides power distribution for light, stage, sound, video and rigging purposes.
- Calculates mono-phase electric loads.
- Puts cables, fuse boards and splitters in place, based on instructions.
- Connects, labels, protects, and secures cables.
- Performs visual inspections for electrical risks.
- Troubleshoots basic problems: checking cables, connections, …
- Acts according to the agreed procedure in case of an electrical accident.

You master following knowledge:

- Basic electrical concepts and calculations
- Electrical Risks
- Protection against electrical risks
- Cables and connections
- (Body protection)
- (Eye and face protection)

You have following attitudes:

- Awareness of invisible risks
- Awareness of others’ behaviour

In the event and theatre sector, we constantly work with electrical appliances. The difference with other sectors is that everything we do is temporary. We start in an empty space with one plug and build a whole electrical system from scratch for a show or an event. At the end of the day, we take everything down again. And the next day, we do the same in another venue. In normal circumstances, we do not interfere with the permanent electrical system of a venue, but we limit ourselves to the part that is temporary. We call this a **mobile electrical system.**

The use of high power electrical systems asks for highly skilled and qualified people. In most countries, you need a certificate or a qualification to be allowed to work on "the inside" of the electrical system. This is why we have to limit ourselves in this chapter to **working under supervision**. This means that whatever we do has to be checked by a qualified person and that the activities we are allowed to do are limited. The exact limitations can depend on the country or the venue you are working in.

Provide power distribution

The motto in providing power distribution for light, stage, sound, video and rigging purposes is **think before you start**. Look for a logical and safe cable route that can serve all the points where you need power (and other signals). A natural route for your cables will follow walls or other paths where people don't walk and where chariots don't ride. This makes it a lot easier to protect them against mechanical impact and avoids tripping hazards. Where possible, the cables are laid over doors, rather than passing in front of them. When you place splitter boxes or other equipment to distribute power, look for places where you need the most connections. Pay attention when crossing **doors**. Cables can be squeezed and damaged. Compartment doors and sound reducing doors need to be closed at all times. This means you can't just run a cable trough them.

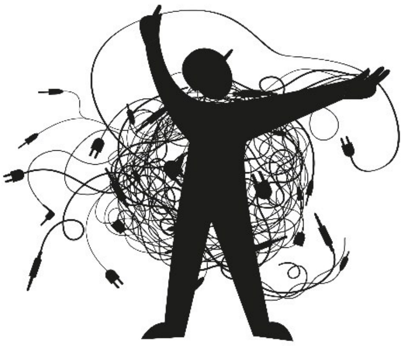


Fig. 6.3.a cable spaghetti

Our work is temporary. When you pull a cable, you will probably take it away again the next day. Therefore, you need to avoid cable paths that are **labour intensive**. Pulling a cable through a hole, placing it under a construction, or wrapping it around a pipe takes a lot of time in the building as well as the taking down phase. Looking for efficient paths and methods will increase the efficiency.

Choosing and checking cables

On stage or in an event, we use different types of cables, with different plugs, different sections, and different configurations. Every one of them has a specific purpose and has its limitations. You need to understand the differences and the consequences in use. A cable must be adapted to the purpose. Key elements in the choice of a cable are:

- **Type of cable**, do you need just an extension cord, a multicore cable or an appliance cable?
- **Type of plug**, what type of plug do you need? Is this the same type on both sides, do you need multiple outlets, are plugs from different countries in use, what connector do you need to have a tension relieve?
- **Material of the cable**, what are the circumstances the cable is used in, what is the expected mechanical impact, what is the possible heat impact, are you working indoors or outdoors?

- **Section of the cable**, what value do the fuses have, how much power will be connected, what is the distance from the power plug to the appliance, is there a risk for convection, are you using composite (multicore) cables?
- **Length**, what is the distance you need to bridge including slack, how did you foresee the path of the cable?
- **Working voltage**, what is the working voltage?

Every time you take a cable, extension cord, splitter box, power bar, or multi socket, you should **inspect** it **visually** for electrical risks. Look for worn out, damaged, melted, burnt or missing insulation and for housing with cracks, holes, loose or missing parts, failing strain relief, or wires sticking out. Damaged material is marked and put aside according to the habits or guidelines of the organisation. If you see riskful situations in a permanent installation or in the equipment in use, notify the responsible person.

Pulling cables

Now that we have chosen the proper cables and know the path they have to follow, we can start pulling cables. Ideally, we have all the equipment like fuse boxes, dimmers, spotlights, active speakers, etc. in place. But sometimes, we prepare for equipment that still has to be brought in or placed. In that case, we will put everything in place without connecting it.

First we **pull** the cables and **connect** them to the appliances. We do not yet secure them. This is only done when a section is finished and tested. This way, we can change things if they don't work and we only have to secure the whole bundle once. This also makes taking them down faster. In large installations, the cables are **labelled** on the side of the power source. This way, we can easily find back a single appliance in a bundle of cables.

In most cases, we will try to bundle as many cables as possible together in the same path. This is easier to secure and keeps the stage clean. There is one exception for this principle. Signal cables can be sensitive to **interference**. In this case we will use a separate route for them. When we have to make them cross each other, we will try to do this in a 90° angle.

We will always have some **leftover cable**, because we work with standard lengths. Try to find a good place in the path of your cables to leave this leftover cable. Avoid leaving it all next to the power box, as this will make a mess of your connections and make error finding difficult. Don't leave the cable rolled up, but put it in long loops, otherwise the cables start heating each other. **Cable drums** should be unrolled completely for the same reason.

Sometimes it is necessary to **connect cables** somewhere in the foreseen path. Avoid doing this in places where there can be mechanical stress on the connection, like driveways. Try to find a spot for the connection that is safe. You always have to secure the connections against accidental disconnecting.

A part of the cables we have to install, are going on height afterwards. We will hang them on **fly bars or trusses**. Avoid winding cables around a pipe or weaving cables inside a truss. This takes a lot of time in the taking down and it doesn't look nice. Cables can be hooked over clamps or S-hooks and when the testing is done, they can be fixed with T-fix or Velcro systems. For long distances, the cables can be double wrapped around the pipe. When both ends are in place, the middle of the cable is wrapped around the pipe and fixed. Avoid tape, since this leaves a residue on the cables. On trusses, the cables can also be put on top and be secured later.

The fact that the pipe or truss needs **to go up** entails that we need enough cable to be able to move the system and to go to full height. The cables will hang down from the truss or fly bar. We have to secure the cables at the point where they go down. This can be done with fasteners or possibly with a clove hitch around the fly bar. It helps to put a long loop on the ground to ensure enough cable to go on height. Cables hanging vertically from a height must be mechanically strong, because they have to carry their own weight.

Even if we try to avoid this, in some cases there is no other possibility than to connect cables **in-air**. Of course we don't want tension on the connectors, because they could disconnect when pulled on. We need to secure the connection in a way that doesn't stress the cable or the tension relieve of the plug, but keeps the connection tight under all circumstances. One way of doing this, is to make a loose knot in the cable and secure the knot to the plug. In this way, both cables are mechanically attached to each other, relieving the stress on the connection.

Outdoors

When working **outdoors**, we need to take specific risks and circumstances into account. The risks for mechanical damage are a lot larger in an environment where trucks and forklifts are driving around. So we have to be sure our cables are well protected. Again, searching for a good cable route is the first step. Cables that **follow the sides of constructions** are automatically protected. But sometimes, we need to protect cables that are crossing public areas or even driveways. This can be done by **fencing off** a cable area, for example between a stage and a mixing booth. When vehicles have to pass, we can put the cables in **cable protectors** like yellow jacks. Another possibility is hanging the cables **on poles or structures**, but we have to take the risk of high vehicles passing by into account. Sometimes, cables are even **dug in** the ground.

When working outdoors, there is also a risk of **water and moisture** penetrating the connections. If events take place over a longer time, there is also a risk for damage by UV radiation. In the first place, we need to use cables adapted to the situation. Ideally we use **as little connections as possible** in places where rain can be an issue. When there is no alternative for putting a connector outside, we put the connectors **horizontally** on **a higher place** than the ground. This way the (rain)water will run off them. Moisture is more difficult to control, even if the connector is under a roof, the moisture can cause oxidation of the metal parts of the connector. Connectors have to be checked for this on a regular base.

Equipotential bonding

Pic. 6.3.1 Equipotential bonding

Trusses, audience seating structures, stages and other metal structures like sea containers need to get an **equipotential bonding**, because they are at risk of being under tension. Faulty electrical equipment or damaged cables can conduct electricity to the structure. Therefore, we need to connect the structures to a specific earth point. Parts of structures that can be touched simultaneously also need to be connected to each other. These connections have to be made with a yellow and green conductor that is connected permanently, in the sense that you need tools to disconnect it. The conductors need to follow another path than the cables of the electrical system. The connections are made with special clamps, made for this purpose.

Testing and troubleshooting

Once all the connections are made, we can test the equipment. This is done by testing every single line. We will probably discover some errors that need troubleshooting. This is mostly done without tools or measuring instruments. First line troubleshooting is based on **systematic, deductive methods**. If problems need more complex solutions, the equipment or the cables are replaced and the faulty equipment goes back to the maintenance department.

The first step in deductive error finding is to **narrow down** the place of the possible errors and to check the most **evident problems**. If a whole set doesn't work, there is probably a power failure. But if one of the two spotlights connected to the same cable is working, than the problem must be somewhere behind the split.

In normal circumstances, we do not work on the "inside" of equipment. One exception is changing light bulbs. Under no circumstances, should you open an electrical appliance that is connected to the power. **Disconnect it physically** before you open it. You preferably do this close to the appliance, so you can visually check the disconnection when working on it. If you use the breakers to disconnect, there is always a risk that someone else will switch it back on. If you use the dimmers, there will still be voltage on the line.

Measuring in installations is done by specialists. This is because of the complexity of the systems, including three phase systems and dimmed power that require a profound understanding of electrical systems.

Sometimes, small repairs are done on site, for example **repairing** an extension cord. Be sure you use the proper tools and methods when doing so. A badly repaired cable can ruin a whole show. Ask a supervisor to check your work if you are working under supervision.

Protect and secure

Once everything works, you can start protecting and securing your cables. Depending on the situation, different methods are used. One general rule is to **leave enough slack** at the end of the cable to be able to focus the spotlight, move the speaker, connect or disconnect when needed, etc. Avoid tension on plugs or cables.

Pic. 6.3.2 Cables under yellow jack

As mentioned before, we will try to choose a cable path that provides a natural protection. Where this is the case, cables only have to be fixed to avoid them form moving. Where there is a **tripping hazard**, we will need to use protection over the full length. You need to try to use as little tape as possible. It is better to tape a **carpet** over the cables. Where there is a risk for **mechanical** damage, like in driveways, we can use mechanical cable protection like yellow jacks.

There is a range of fasteners to secure cables, but not all of them are environmentally friendly or suitable for temporary use. Tape is very difficult to recycle and most tie wraps are not reusable. Alternatives like T-fix or Velcro are better solutions. Do not make knots in a cable in any circumstance. This will damage the copper leads on the inside.

Power distribution boxes and dimmers

Power distribution boxes are boxes that contain all the **wiring, switches and safety appliances** needed to distribute power from one source to multiple sources. You can compare this with the fuse box at your home. The difference is that all connections to the outside are made with plugs because we use them for temporary installations. Electrically speaking, **dimmers** are also distribution devices. The difference is that the dimmer will also adjust the amount of power going to a spotlight.

Power distribution boxes split one (mostly high power) input into multiple (lower power) outputs. Every (set of) output(s) is separately secured against **overload, short-circuit and residual current**. The input is often a three-phase plug, and the distribution box will divide this in monophasic outputs. In countries where there are different types of three-phase power grids, the distribution box will also contain a switch to adapt to the different grids. Some distribution boxes contain extras like measuring and monitoring equipment.

Pic. 6.3.3 dimmer street

The boxes are placed on strategic places, to minimise the amount of cable we need and to ensure **quick intervention** in case of a problem. In large events, different activities will have different distribution boxes. This improves **operational security**. When an error occurs on stage, this will not influence the audience area.

Even if the operation and organisation of the distribution boxes is something for specialists, there are some properties that are important when pulling cables. You need to know what outputs are **at the same fuse or breaker** and what the **maximum power** per (set of) outputs is. You will probably need to calculate the power, based on the current given on the breakers.

Switching on

Switching the power on or connecting it to the power system of the building should be done by the person responsible for the installation. This includes measuring three phase power supplies and is specialists' work. It is important to have the necessary skills and training to do so. In some countries, you also need a qualification for this. This person will keep an overview of the whole installation and will know the consequences when powering the whole installation. **Do not turn a fuse back on** without asking the person responsible. You don't know why it has been turned off or why it has blown. Turning it on can endanger other persons.

Taking down

Taking down is preparing for the next show. If the cables are rolled, checked and stored in a proper way, half of the work for the next show is already done. If possible, switch off the power first, but you must be sure you don't need power anymore. The working lights or the motors for rigging might still need power. If this is the case, you can switch off parts and take these down already. The next step is to disconnect and to undo all cable protection and attachments. Perform a visual check again when you are rolling and packing the cables. Sort the cables in the proper boxes, according to the organisations habits. This way, you are ready for the next job.

When working **outdoors**, clean the cables before or during coiling. Look out for glass etc. that can stick on cables in combination with dirt or sticky beer residue. Use gloves to coil these cables.

Coiling a cable

Coiling a cable or extension cord in a proper way is not only good for efficiency or aesthetics, but it also protects the cable from damage. Every cable has a natural coil and if you roll against it, you get **twists and kinks**. The wires on the inside will also twist and bit by bit the wire will break.

The trick is to keep the natural coil in the cable. The best way to do this is the “butterfly method”, also called the “**under-over method**”. Take the end of the cable in your left hand with the plug towards you and take the cable at a length that will form the loop with your right hand, between thumb and fingers. Twist the cable slightly, so that it forms a natural loop. The end of the loop will lie on top. For the next loop, you continue, but now you turn the second loop the opposite way. The end of the second loop will now lie under the cable. After this, you repeat the two loops till you reach the end of the cable.

The advantage of this method is that when you lay out the cable again, it will have no torsion and lie flat on the ground.

The alternative method with all loops in the same direction causes one 360° twist for each loop you make. This works for very flexible cables, but still can cause kinks. **Do not ever roll a cable around your elbow**. The tension and the short loops damage the wires inside the cable.

Once the cable is coiled, **fix it** with a durable method. This can be hook and loop fasteners like Velcro cable ties or T-Fix rubber ties. These methods don't leave glue residue on the cable and are good for the environment.

Pic. 6.3.4 T-fix

Heavy cables can sometimes be coiled directly in the box, in this way you don't need to lift the weight of the whole cable.

First aid in the event of an electric shock

Even if we do everything in our power to avoid accidents, there is always a possibility that something goes wrong. This means you have to **be prepared** to act in case of an accident. The most common accident is an electric shock. When touching an unprotected wire or the metal part of an appliance under tension, a current can flow through the body causing a shock. Depending on the path of the current, this can be accompanied with forceful muscular contractions. The result of an electric shock can be unconsciousness, burns at contact points, internal burns, neck injury, cardiac arrest, broken bones, brain damage etc.

When a victim is still in contact with live voltage, first **switch off the voltage** before doing anything else. If you don’t, there’s a serious risk that when you touch the victim, you get an electric shock as well: this means an additional victim, and one less person to help. Be aware that in some circumstances, switching off the power can cause the victim to fall. When you cannot switch the power off quickly enough, **use isolating materials** (dry clothes, a book to stand on,…) to handle the victim. Avoid touching the victim’s skin, or touching grounded conductive parts at the same time.

Ask someone to **call the emergency services** immediately in case of a serious shock.

When the victim is detached from the voltage: **check consciousness and respiration**. If a person is unconscious, always call emergency services. If a person is not breathing and/or has no pulse, remediating this has priority over anything else after emergency services have been called. If you are not sure what to do, ask them about it. Electrical injury is frequently associated with explosions or falls that can cause severe additional injuries. You may not be able to notice all of them. **Do not move the person's head or neck** since the spine may be injured.

Fig. 6.3.b Switch board

If the person is **faint, pale, or shows other signs of shock**, lay him or her down, with the head slightly lower than the trunk of the body and the legs elevated, and cover him or her with a warm blanket or a coat. Never give any **drinks or food** to a person that has had a serious electric shock. There could be damage to internal organs, which will get worse by drinking or eating.

Any **skin burns** should be cooled under moderately cold, preferably drinkable, running water. If no drinkable water is available, it is still better to cool serious burns with less clean water than not to cool them at all. Be careful when using water in an electrical environment. Cooling with water should be applied as quickly as possible, and during a prolonged time (at least 20 minutes).

Stay with the person until medical help arrives. A person who has had a serious electric shock should always get a **medical check-up**, even when shortly after the shock everything seems all right. Some effects of an electric shock (mainly kidney failures) only become noticeable up to more than 24 hours later, often when it has become unclear that they are related to the accident.

Twisted cables

When a cable is twisted, it can be hung over the full length and left in the stage tower to untwist. It can help to hang a small weight on it or even to connect an electrical load to the cable. The heat that is produced by the load will untwist the cable. Some cables have kinks that are irreversible. The only thing that is left to do then is to throw the cable away.

Following cables

Sometimes, we connect a cable to an object that needs to move during a performance. This can be a set piece, a camera, a rolling spotlight, etc. To avoid the cable getting tangled up when the object is moving, the cables are laid out in an eight shape, with the moving end on top. The cable will "follow" the object and pull a loop from the stack without getting tangled.

Terms and definitions

- power distribution
- mono-phase
- three phase power grid
- cables
- fuse board
- fuse
- breaker
- splitter
- electrical risk
- electrical appliance
- mobile electrical system
- working under supervision
- cable route
- plug
- section (of a cable)
- interference
- cable drum
- in-air connection
- equipotential bonding
- deductive method
- extension cord
- overload
- short-circuit
- residual current
- coiling
- under-over method
- electric shock

7.1 Basic electrical concepts and calculations

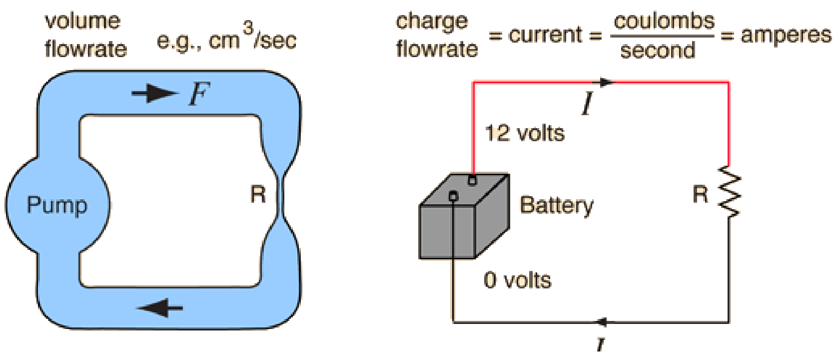
At the end of this block, you:

- Understand the concepts of voltage, current, resistance and power.
- Understand the relation between voltage, current, resistance and power.
- Perform simple electrical calculations.
- Understand the difference between AC and DC.
- Understand the principles of series and parallel connection of loads.

In this module, you will get a brief reminder on the basic concepts, units and calculations for electrical energy.

Voltage, current, resistance

Comparing the concepts of electricity with those of a water flow usually helps to make them clearer. Although this comparison has its limits, it is certainly useful for a first practical understanding.



Dia 7.1.1 Electric current has some similarities with a water flow

The left side of Figure 1 above shows a water circuit consisting of a pump, some rather wide tubes to guide the water, and a narrow passage to represent the load of the circuit.

The right side of the figure shows the electric equivalent of this water circuit example: a battery, connected by wires to a load (here represented by a resistor, R). Instead of water, electric charges are moving inside of the circuit.

Water circuit	**Electrical circuit**
The pump imposes a force on the water particles. This results in a *pressure difference* between one part and the other part of the circuit. The pressure difference can be expressed in *kilograms per square meter*.	The battery imposes a force on the electric charge in the circuit. This results in a difference between one part and the other part of the circuit: this is a voltage difference, often simply called **voltage**. The unit of voltage is **Volt (V).**
As a result of the *pressure difference*, water starts to flow from the high-pressure section to the low-pressure section.	As a result of the **voltage difference**, an electric charge starts to flow from the area of high voltage to the area of low voltage.
The volume of water per second that passes a certain place in the circuit is called volume *flow*. The unit is *litres per second*.	The amount of electric charge per second that passes a certain place in the circuit is called **current**. The unit of current is **Ampere (A).**
A narrow tube will oppose a water flow more than a wide tube. This opposing force is called *flow resistance*.	A thin wire will oppose the electric current more than a thick wire. This opposing force is called **electrical resistance.** The unit of resistance is **ohm (Ω).**

In the figure, the voltage on one battery connection is said to be 0V, on the other one it is said to be 12V. So the **voltage difference** across the battery is 12V. Technically speaking, a single place in a circuit cannot have a voltage just on its own. Voltage can only appear as a voltage difference between two places. But very often we will choose one place as the reference of 0V, and compare all other places with that same reference. In practice, the earth or ground is quite often chosen as the reference of 0V. When we say “this connection point is at a voltage of 230V”, it is just a simpler way of saying: “The voltage difference between this point and the earth is 230V”.

In real life, voltage differences between a part of a circuit and the earth or ground play a very important role when it comes to electrical safety.

The electric dimensions of voltage, current, power and resistance are denoted with symbolic letters:

Dimension	Symbol	Unity	Example
Voltage	V (or U)	Volt (V)	V= 9V
Current	I (“*intensity*”)	Ampère (A)	I=12A
Power	P	Watt (W)	P=100W
Resistance	R	Ohm (Ω)	R=10Ω

Note that in some non-English speaking countries, U instead of V is used as the symbol of voltage.

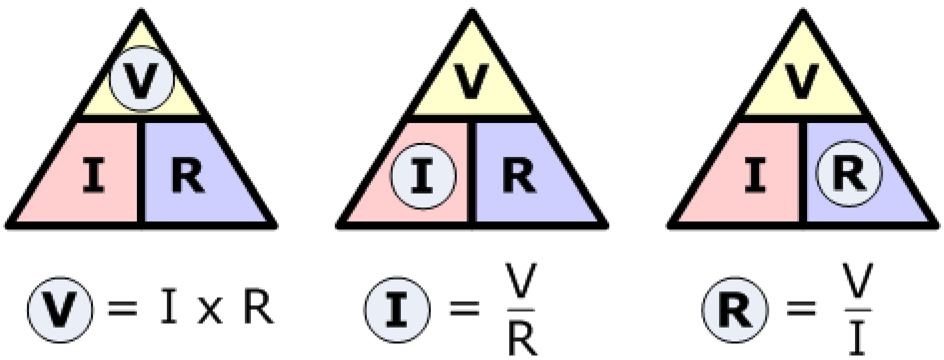
Ohm’s Law

Ohm’s Law is one of the most fundamental laws of electricity, with a lot of practical applications. It states that the electric resistance R of an electric load or a conductor is calculated by dividing voltage V in volts by current I in amperes:

Building on the previous examples:

- A halogen bulb of 12W at a voltage of 12V uses 1A. Therefore, its normal resistance is 12V divided by 1A =12Ω.
- A light bulb of 100W at 230V uses 0,43A, therefore has a resistance of 230V/0,43A = 535Ω.
- A 12V version of a 100W bulb would have a resistance of only 12V/0,43A = 27,9Ω

Ohm’s law can also be shown in a triangle. When you cover one dimension with a finger, the formula to calculate this dimension is left visible.



Dia 7.1.2 Ohm's law

At first glance, the concept of resistance seems less directly related to safety than that of voltage or current. But actually, it is equally as important as the other two. To give but one example: if the resistance of a poorly made connection is too high, it can cause overheating or even start a fire when large currents flow through. A large current running through an important resistance will produce a voltage across it (since V=IxR). This voltage combined with the same large current will result in a large amount of power (since P=VxI). Power always means transformation to another form of energy, in this case this will be heat.

Power

When we want to drive a water mill, we need both water pressure and water flow acting together. There’s no point in having a lot of pressure, when not enough water can flow and move the mill. Also, a large amount of water is of little use if it would be halted by our water mill, just because there is not enough pressure to keep it flowing.

Much in the same way, we will need a combination of both voltage and current if we want to use electrical energy. This combination of voltage and current is called electric **power**. By multiplying the voltage with the accompanying current, we get the amount of available power in **watts (W).**

Power = Voltage x Current

Watts= Volts x Amperes

Electric power always means that electric energy is transformed to some other energy form. Very often, this will be heat, but it can also be light, movement, or any other energy form, or a combination of several different energy forms.

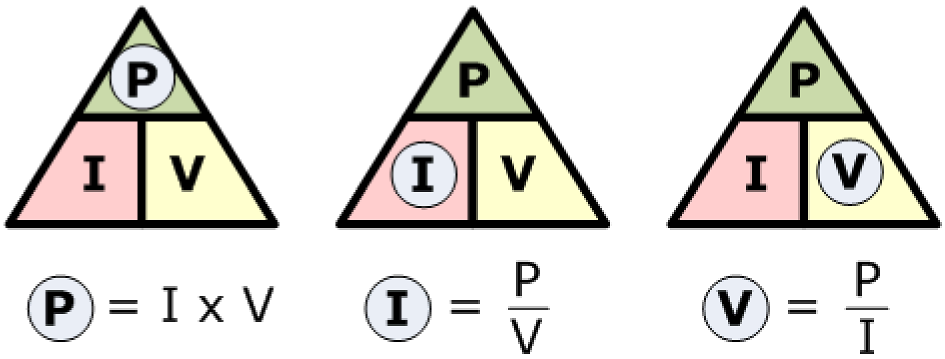
Examples

Some real examples of practical voltages, currents and powers.

- A 12V halogen lamp with a power of 12W will draw 1A from a power source with a voltage of 12V, since 12V x 1A makes 12W.
- A light bulb of 100W connected to a voltage of 230V, will draw a current from about 0,43A, since 230V times 0,43A makes 100W. However, if I want to produce the same 100W with a voltage of only 12V, the voltage source needs to provide a current of 8,3A: 12V times 8,3A makes 100W.
- A theatre spotlight of 1000W at a voltage of 230V will need about 4,3A of current to produce its full output.
- In most cases, a common power outlet in a modern domestic electric installation is able to deliver about 16A to 20A at a voltage of 230V.
- Power outlets commonly used in stage situations can deliver currents a high as several hundreds of amperes.
- A small red led for signalling purposes needs a voltage of about 1.6V, at a current of about 0,02A. So it takes an amount of power of only 1.6V x 0,02A=0,032W.

Calculate Power

You will often need to calculate power from voltage and current, for instance to determine how much equipment you can connect to a certain power source or outlet. To remember the power calculation rules more easily, the so-called voltage-current-power triangle can be useful. Remember that “Power is at the top” when drawing the triangle. When you cover one dimension with a finger, the formula to calculate this dimension is left visible.

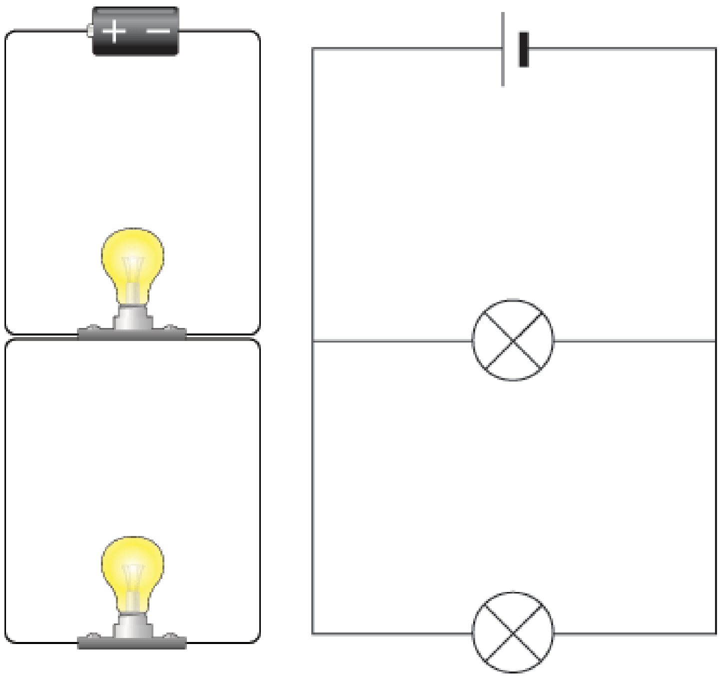


Dia 7.1.3 power calculation

Connection of loads or sources

In practice, we will often connect more than one load to a supply. Therefore, we need to understand what happens when we make different types of connections.

Parallel connection of loads



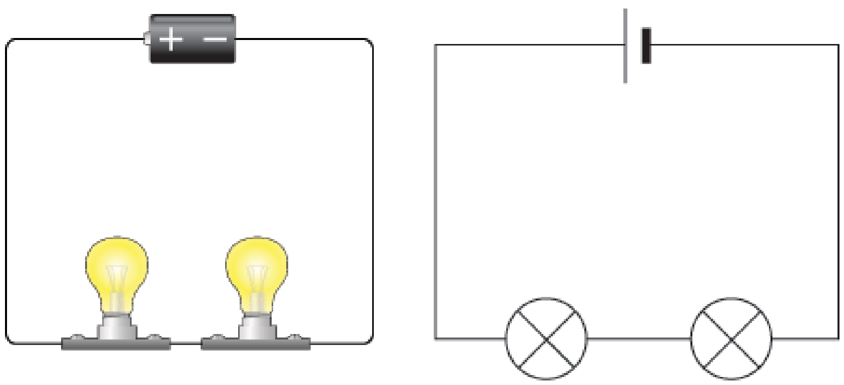
Dia 7.1.4 Parallel connection of loads, in this case 2 lamps connected to a battery

When several loads are connected to the same power source in the way shown in Figure 4, they are all connected to the same voltage. This is called a parallel connection. A very common example of a parallel circuit is the typical splitter block used to connect several appliances to the same mains outlet. Each load gets the same mains voltage of 230V (in Europe).

In a parallel circuit, each load gets its own current, and these currents can have different values. We can add up the currents flowing to each load to calculate the current provided by the source. If one load is disconnected, the others keep working. This also means we can add up the power values of all loads to get the total power to be delivered by the source.

On a stage, we will mostly make parallel connections to put spotlights on the same circuit, to connect several speakers to the same amplifier output, and so on. Exceptions do occur, but these are much less common.

Series connection of loads



Dia 7.1.5 Series connection of two lamps and one battery

Another way of connecting loads to the same power source is shown in Dia 7.1.5.

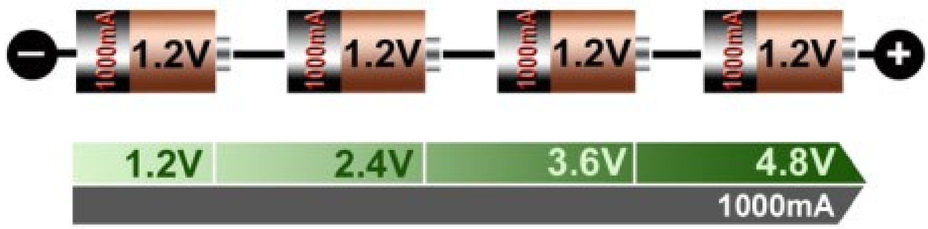
Here, the loads are connected in such a way, that the same current is flowing through each load successively. So every load gets the same amount of current. But the voltage the loads get, is not the full voltage of the source anymore. Instead, we now have to add up all the voltages across all loads, to get the voltage of the power source.

Also, the resistances of the individual loads can be added up to get the total resistance of the series circuit. When one load is disconnected in a series circuit, current flow will stop for all other loads as well. Stage examples of series circuits are luminaires like simple (passive) sunstrips.

Also in series circuits, we can add up the power of each load to get the power the source needs to provide.

Series connection of voltage sources

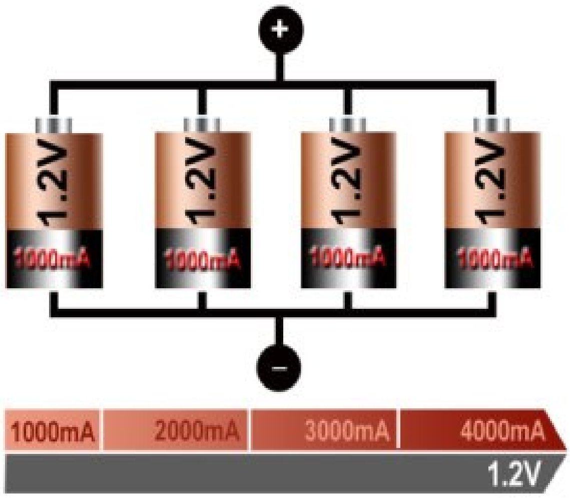
Not only loads, but also electric voltage sources can be connected in series.



Dia 7.1.6 Series connection batteries.

This frequently occurs when we put batteries in a device, and in this series circuit, the total amount of voltage will be the sum of all individual voltages. The same amount of current will flow through all the batteries, and in most practical cases it is recommended that the individual batteries are of the same type and have about the same condition.

Parallel connection of voltage sources



Dia 7.1.7 Parallel connection batteries

Voltage sources can also be connected in parallel. In that case, the voltage of the individual batteries should be almost equal, if we want to avoid that electric current is flowing out of one battery into another one. The total voltage will be equal to the voltage of each individual cell, but the total amount of current that can be delivered will be the individual current times the number of batteries.

AC and DC: Alternating and direct current

In a theatre or event environment, we will mainly work with electricity that comes from a power grid, and less with battery sources. To transport the electricity in the power grid, we use alternating current. Batteries produce direct current. It is important to understand the difference, because the type of current has consequences for safety.

Direction of current flow

Until now, we have seen examples of electric currents that flow in one direction. We took it for granted that current flows from a higher (=more positive) to a lower (=less positive) voltage. So current flows from the positive pole to the negative pole from a voltage source like a battery. This way of describing electric currents is known as the **conventional flow**. If no more specific information is given, we will assume conventional flow, from positive to negative, is referred to.

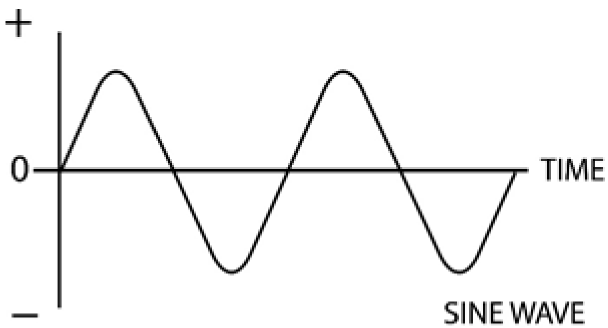
Conventional flow is nothing more than a standard that was agreed upon in the early days of electricity. Only several decades later, it was discovered that the particles that actually move in an electric circuit are electrons, and that they have a negative charge. The movement of the electrons in the external circuit is from negative to positive, so they are moving in opposite direction than the conventional flow. To avoid the hassle of having to change the agreed direction of electric current, and because it doesn't have major consequences for working with simple practical circuits, it was decided to keep working with the convention of current flow, from positive to negative. The difference between both ways of viewing only becomes relevant in the realm of more advanced physics and electronics.

Direct current and alternating current.

To explain the basic concepts, we used the example of a battery. We only described electric currents that are flowing in just one direction: the conventional flow, from positive to negative. This is called DC (Direct Current). Direct current has a constant polarity: the positive and negative sides of the voltage are always at the same place. It is the kind of current that is delivered by power sources such as:

- Batteries
- Accumulators
- Solar panels
- The output side of most (but not all) low voltage power adapters.

On stage however, more often we will work with power connected to the power grid. This means we work with another type of current, called AC or Alternating Current. Alternating current does not follow a constant direction, but instead changes its direction periodically, mostly in a regular pattern like the one of this picture.



Dia 7.1.8 Sine wave

As you can see, polarity is changing all the time. It follows a cycle from zero to a positive maximum, then back to zero, then to a negative maximum, and then back to zero again. This complete sequence is called a **period** or a **cycle**.

This is the type of current delivered by domestic and industrial power connections and outlets.

This means that these connections need to provide alternating voltage, which causes an alternating current to flow.

Mains voltage has 50 cycles (in Europe) or 60 cycles (in US) per second. This number of complete cycles per second is called **frequency**. The unit of frequency is Hertz (Hz). So the frequency of the mains voltage in Europe is 50Hz, in the US it is 60Hz.

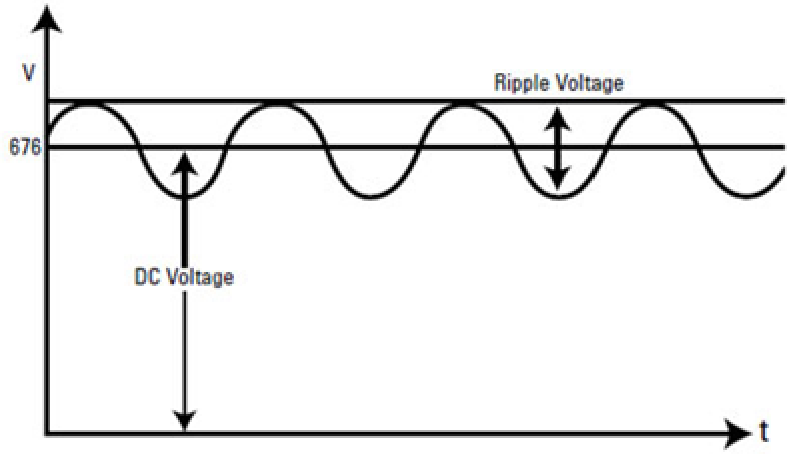
Alternating Current has some advantages over Direct Current:

- Voltages can be changed to other values by a simple transformer. To do the same with DC, a more complicated circuit is needed.
- The frequency can help to drive motors with a certain speed (rotations per minute, rpm).

AC also has a few disadvantages.

- The most important with respect to safety is that an electric shock from an AC source has more serious effects than a shock from a DC source with the same voltage.

AC and DC currents and voltages can also appear together, and combine to what is called a DC current or voltage with a **ripple** (see Dia 7.1.9).



Dia 7.1.9 DC voltage with ripple

This is a current (or voltage) that changes quickly over time, can even have a value of zero at some moments, but never changes its direction or polarity.

The practical importance of this is that the hazard of an electric shock of a DC source with ripple lies somewhere between that of an AC and a DC source with the same voltage.

What you need to remember

- The symbol for Voltage is V (or U) and the unit is Volt (V).
- The symbol for Current is I (“intensity”) and the unit is Ampère (A).
- The symbol for Resistance is R and the unit is Ohm (Ω).
- The symbol for Power is P and the unit is Watt (W).

- V = I x R
- P = I x V

- When loads are connected parallel
- the voltage over the loads is the same.
- the current is divided over the loads.
- the total power is the sum of the power of the different loads.
- When loads are connected in series
- the current through the loads is the same.
- the voltage is divided over the loads.
- the total power is the sum of the power of the different loads.

- Direct current has a constant polarity: the positive and negative sides of the voltage are always at the same place.
- Alternating current does not follow a constant direction, but instead changes its direction periodically

- Mains voltage has 50 cycles (in Europe) or 60 cycles (in US) per second. This number of complete cycles per second is called frequency. The unit of frequency is Hertz (Hz).

Terms and definitions

- voltage
- Volt (V)
- current
- Ampere (A)
- resistance
- Ohm (Ω)
- power
- Watt (W)
- voltage difference
- Ohm’s Law
- parallel connection
- load
- series connection
- alternating current (AC)
- direct current (DC)
- current flow
- power grid
- sine wave
- period
- frequency
- ripple

Rehearsal questions

07.01.01 Electric charge flows as a result of

a) voltage difference.
b) current.
c) electrical resistance.

07.01.02 connect

a) Resistance
b) Power
c) Current
d) Voltage

1. Watt
2. Volt
3. Ampere
4. Ohm

07.01.03 A halogen bulb with a voltage of 12V uses 1A, the resistance is

a) 1 Ohm
b) 12 W
c) 12 Ohm

07.01.04 A light bulb has a resistance of 220 Ohm and is connected to a power source of 110 V, the current is

a) 0.5A
b) 1A
c) 2A

07.01.05 A power outlet of 220V 16A can deliver

a) 2530 W
b) 3520 W
c) 5230 W

07.01.06 When two loads are connected in parallel,

a) the current through the loads is the same.
b) the voltage over the loads is the same.
c) the power of both loads is the same.

07.01.07 A load of 1000 W and one of 1500 W are connected in series, the total load is

a) 500W
b) 1000 W
c) 1500 W
d) 2500 W

07.01.08 Three batteries of 1.5 V are connected together, the output is 3 V, the batteries are connected in

a) series.
b) Parallel.
c) None of the above

07.01.09 The current through a battery is

a) AC
b) DC
c) Ripple

07.01.10 True/False

- DC voltages can be changed to other values with a transformer.

7.2 Electrical Risks

Before you start, you should read 07.01 Basic electrical concepts and calculations.

At the end of this block, you will:

- Understand the risks of an electric shock, an arc-flash, overheating and fire.
- Be able to perform a simple risk evaluation of a situation where electricity is involved.

When you work with electricity, there are several risks can that occur in practice. The main risks are electric shock, overheating of conductors and arc flash. In this text, you will get an overview of different risks caused by electricity.

Electric shock

A person will experience an electric shock when an electric current is **flowing through his or her body**, even when this current is relatively small. A current flows through the body when body parts are touching objects with a different voltage level. The human body then becomes a conductor. The ground is usually at voltage level zero.

Examples:

- You touch an ungrounded spotlight with faulty isolation, while at the same time touching a grounded metal structure of the theatre.
- You try to repair a wall outlet without disconnecting it from the mains electricity, and you touch bare wires or contacts.

A greater current will result in a greater risk, but this risk also depends on several other factors, such as:

- the path of the current through the body
- the magnitude of the current
- the type of current (AC, DC with or without ripple)
- the duration of the current flow
- the health and condition of the person getting an electric shock

Path of electric current through body.

An electric current can flow through the body in several ways. The most common possibilities are:

- Between different areas of the **same part of the body**, for example between fingers of the same hand
- Between **two hands**
- Between **one or both hands, and one foot or both feet**. This can easily happen when someone is not insulated from the ground.

The last two possibilities are far more dangerous than the first one, because current will flow very **close to the heart**, probably affecting both heart and chest muscles, with potentially lethal effects. A current between several fingers of the same hand can also cause serious injuries (like severe burns), but is less likely to be lethal.

Fig. 7.2.a spotlight

Effects of electric current through body: magnitude of the current.

In general, an AC current flowing from one hand to both feet will produce a range of effects, depending on the magnitude of the current:

- 0 to 0,5mA: imperceptible
- 0,5 to 5mA: perceptible, but no muscle reaction
- From 5mA on: muscle contractions with reversible effects
- From 30mA on: muscle contractions with possible irreversible effects, like the inability to let go again.
- The probability of heart fibrillation increases with the amount of current, and becomes more than 50% from 100mA on.

When currents are even higher, other serious effects can happen: severe burns of outer skin or inner tissue, crucial damage like kidney failure, clotting of proteins, chest muscle contraction causing breathing to become difficult,…

Type of electric current (DC or AC, frequency).

When the magnitude of the current and all other circumstances are equal, an **AC current flowing through a body is more dangerous than a DC current**. The risk produced by a DC current with some ripple lies in between the previous two. Alternating current is much like the electric nerve pulses that control our muscles, including our heart muscles. It will cause ongoing muscle contractions (where DC will only cause a contraction at the moment the circuit is closed or opened). AC current can create a situation where the victim cannot release his grip onto the live parts he has grasped.

The risk also depends on the **frequency of the AC** current. Unfortunately, the 50 or 60 Hz of the mains voltage happens to fall in the range of the most dangerous frequencies. This is because they are very close to the nerve pulses that control our heart, and hence they are most likely to interfere with them, causing fibrillation and other severe heart failures.

The duration of the current flow.

Effects will be more serious when the current is flowing through the body during a prolonged time. Very short lasting currents (order of magnitude in milliseconds) can possibly have only mild effects. That's why a protection device should trip fast enough, reducing the risk to an acceptable level.

Health condition

The health condition of a person can influence the result of an electric shock. Heart diseases increase the risk, but also, for example, open wounds that lower the electrical resistance of the skin.

What is a dangerous voltage?

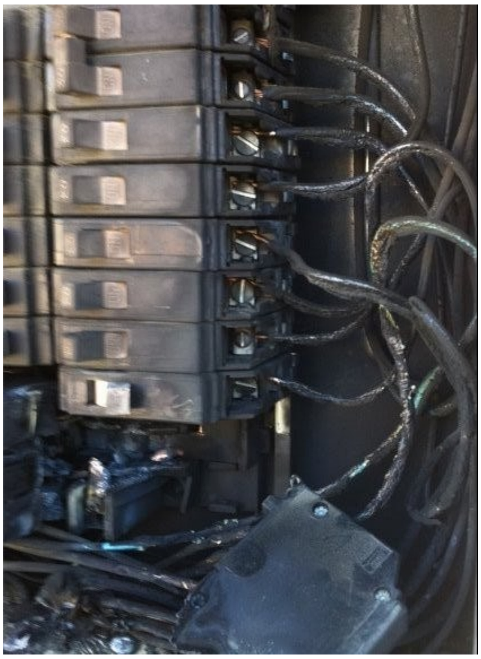
Since the magnitude of the current is the most important parameter when judging the risk involved with an electric shock, the next question is: how much voltage is required to produce a dangerous amount of current? According to Ohm's law, this depends on the resistance of the human body. This resistance, however, is not a constant value, and depends on several circumstances. Practically, the most important one to be taken into account is the **humidity of the body**. A skin that is dry or just a little sweaty will have a higher resistance than a skin that is wet, or even largely submerged. A voltage applied to a dry skin will only become dangerous at a higher voltage than a voltage applied to a wet skin, or to a submerged human body. This adds to other factors like the surface of the contact area.

Overheating, smoke and fire.

Overheating of conductors or other parts of an electrical circuit is caused by a current that is too large with respect to the resistance and the amount of cooling of the conductive parts.

Some examples:

- The **section surface** (or wire gauge) of a conductor should be large enough for a given current, or else it will overheat.
- **Connections** such as plugs or terminals should have a very small resistance, otherwise local overheating will occur. In general, this means that contacts should be firmly attached, with enough mechanical tension between them.
- Cables need a sufficient amount of **air convection** to prevent overheating. A cable rolled up on a cable drum might overheat, while the same cable gets sufficient cooling when spread out over its whole length.



Pic. 7.2.1 electric cabinet fire

In the first place, the insulation of the cable or the housing of the plugs will melt. When the situation continues, smoke and fire can be more extreme possible consequences of overheating.

Overload and short circuit.

Overload and short circuit are two elements that can provoke a risk for fire. These are two different conditions:

- **Overload** means that the whole of the connected loads has a power consumption that is too large for the electrical wiring. It is very often the result of some calculation or estimation error. In an overload condition, current will be anywhere between slightly too high and up to 5 times the normal current. Depending on the situation, the effects of an overload can take some time before they become clearly noticeable. The wiring will heat up, and at a certain point it will burn or start producing smoke.
- **Short circuit** means that an unwanted direct connection is made between the two poles of a power supply, in fact we create a load with almost no resistance. This provokes an unwanted and extremely large current. This is very often the result of a faulty electric component, or of some kind of incident or accident (like dropping a conductive tool in an switchbox, or misconnecting a conductor). When a short circuit occurs, the amount of current becomes suddenly extremely high (like 10 times or 100 times the normal current, possibly even more). A protective device should disconnect the power as quickly as possible.

Solid or stranded conductors

When a bad connection occurs in an electric circuit, the resistance of the circuit will be higher than normal at a specific place. This can lead to overheating and the start of a fire. Typical places where this happens, are screw connections, or other places where several conductors are connected together. Stranded conductors can be an important risk, because it is difficult to guarantee that all strands are effectively used to make the connection. When some are missing, the conductor will have a locally diminished section surface, a **locally augmented resistance** and overheating might occur. Therefore, normally solid conductors are used to build permanent electric circuits. If stranded conductors are used, the strands should be kept together with wire ferrules.

Risks of smoke production

Any overheating or flames can produce smoke. Because the insulation and the casing of the plugs are mainly made out of plastics, the smoke can be **toxic**, and seriously **limit visibility**, making the evacuation of people difficult. Specific types of cable will produce less toxic or less optically dense smoke.

Fire

Heat in combination with combustible materials can start a fire. This can happen when a bundle of cables overheats because of overload or lack of cooling. When the heat is intense enough, it will ignite materials that are close. Even less combustible materials can catch on fire, a typical example is burning insulation in the vicinity of an overheated contact point in a distribution box.

Arc Flash

Pic. 7.2.2 Arc flash

An arc flash can occur when a large electric current is switched on or off by inappropriate means. An arc flash is essentially a spark that is out of control. Normally air is an excellent insulator. But when its temperature rises high enough, it becomes conductive. This is the principle of electric welding. In that case, however, the arc is well controlled by limiting the amount of current. With an accidental arc flash, this is not the case.

Causes of arc flashes

Arc flashes are likely to occur **when a large current is switched on or off too slowly:** when the switching contacts are not moving fast enough towards or away from each other. Normally an appropriate switch is constructed in such a way that switching is performed fast, and arc flash effects are prevented or kept within safe limits.

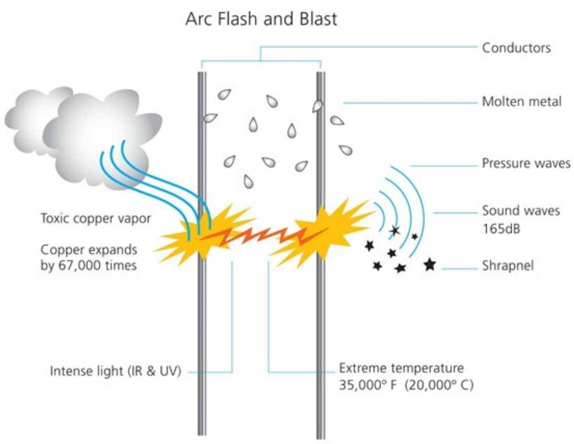
Examples of risk for arc flash risks include:

- A **short circuit or accidental disconnection**: damage to cable or connection, wires accidentally touching each other or being cut, metal objects such as ladders or other devices touching blank conductors or contacts, failure of equipment.
- Connecting or disconnecting a large current with a **device which is not designed for it** (like a CEE connector, or a switch or breaker that does not meet the requirements for such a large current). In general, when the speed of switching depends on the operator instead of the mechanical construction of the switch itself (spring loading etc.), the device is not appropriate to switch any larger current. That's why switching with plugs, bare contacts or wires always constitutes an arc flash risk.
- **Work or repair electric circuits under voltage**: dropping or hitting conductive tools onto connections, trying to replace fuses, lamps or other components without first switching off voltage.
- Inappropriate use or failure of measuring tools.

Please note that arc flashes do not necessarily need a high voltage in order to be dangerous. It is mainly the amount of current that is hazardous: the larger the current, the greater the risk. A battery of a car, truck or genie lift can easily deliver enough current to produce a rather large arc flash, even when voltage is only 12 or 24V. The fact that the arc of a DC current is less easily extinguished adds to this, because unlike an AC current it does not periodically become zero.

Effects of an arc flash

Even rather small arc flashes can already produce serious injuries, for instance when only one hot shrapnel or droplet of molten metal is projected into an eye.



Pic. 7.2.3 Overview of arc flash effects

An arc flash can produce several hazardous effects:

- **Radiation**: Heat and UV radiation can cause serious burns, especially on face and eyes, and hands or arms. Intense light can damage eyes, and in extreme cases even cause blindness.
- The extreme heat of an arc flash can result in **melted, hot metal particles** and shrapnel flying around. The heat can also ignite other materials, and possibly start a fire.
- The **sound level** produced by a larger arc flash can cause serious hearing damage.
- **Toxic smoke** can be produced.
- A larger arc flash can also lead to an arc blast: a **shockwave** that can overturn or push away people. Very large arc blasts are actually explosions.
- Objects like tools or measuring leads can be "**welded**" together by the arc, which can make it difficult or even impossible to withdraw them.
- Even when some small arcs do not result in personal injury, they can **damage equipment**, especially when they occur repeatedly. They will reduce the lifetime and reliability of switching contacts, and possibly weld them together, so they do not open as expected anymore. This can indirectly cause other dangerous situations.

What you need to remember

When you work with electricity, the main risks are electric shock, overheating of conductors and arc flash.

A person will experience an electric shock when an electric current is flowing through his or her body. The severity of the risk depends on:

- Path of electric current through body
- Magnitude of the current
- Type of electric current (DC or AC, frequency)
- The duration of the current flow

Overheating, smoke and fire can be caused by:

- Overload, which means that the whole of the connected loads have a power consumption that is too large for the electrical wiring.
- Short circuit means that an unwanted direct connection is made between the two poles of a power supply

An arc flash occurs when a large electric current is switched on or off too slow. An arc flash is essentially a spark that is out of control.

Terms and definitions

- electric shock
- overheating of conductors
- arc flash
- dangerous voltage
- smoke
- fire
- section surface
- wire gauge
- overload
- short circuit
- stranded conductor
- switching
- UV radiation

Rehearsal questions

07.02.01 An electric shock is most dangerous when the current flows

a) between different areas of the same part of the body.
b) between two hands.
c) between two feet.

07.02.02 True/False

- AC is less dangerous than DC.

07.02.03 To avoid overheating, the resistance of connections like terminals should be

a) low.
b) high.
c) Doesn't matter

07.02.04 A short circuit has a resistance that is

a) average.
b) extremely low.
c) low.

07.02.05 Stranded conductors create a higher risk for overheating in terminals because

a) you can never be sure all wires connect properly.
b) there is air between the wires.
c) they are flexible.

07.02.06 True/False

- Air becomes conductive when the temperature rises high enough.

07.02.07 True/False

- Unplugging a power connector can cause an arc flash.

07.02.08 True/False

- An arc flash can only occur above 155 V.

7.3 Protection against electrical risks

Before you start, you should read 07.02 Electrical Risks..

At the end of this block, you can recall the different safety devices, protection classes, IP Codes and procedures for the protection against electrical risks..

In the event and theatre sector, we constantly work with electricity and we do so in all kinds of circumstances. The consequence is that we are permanently exposed to electrical risks. The most important risks are electric shock, the effects of overload and short circuits, and arc flash. We tackle these risks using proper methods, adapted equipment and sensitive safety devices.

Protection against electric shock

The main prevention measure against electrical shock lies in **switching off** mains voltage whenever an electrical risk is present. If there is no voltage, there is no risk. But this would probably also mean that we are no longer able to work. So other measures have to be taken.

To determine what measures should be taken against the risk of an electric shock, we have to discriminate between two important situations:

Direct contact

Direct contact means that somebody touches electric parts that can normally carry a voltage. It is to be expected that a voltage can appear there, since this is part of the normal operation of the circuit or equipment.

If one touches a connection inside a switchboard, or receives a shock because he touches an outlet contact by means of a conductive screwdriver, then these are clear cases of direct contact: it is normal and to be expected that a dangerous voltage can be present there. Please note that it is not relevant whether you make immediate contact, or by way of some intermediate conductive object (like a tool): both are examples of direct contact.

Protection against risks of direct contact (basic protection) can be achieved

- by means of **proper insulation**.
- by forcing people to keep an large **enough distance**.
- by using **SELV** (Safety Extra Low Voltage).
- It cannot be achieved reliably by grounding or residual current devices, since the difference between a normal current and a current trough the human body is difficult or impossible to make in this case.

Indirect contact

Indirect contact means that somebody touches a conductive part that normally should not carry a voltage, but happens to do so now, because of an insulation fault or other cause. The conductive part is usually a **metal housing** (also called a "mass") of equipment like stage luminaires, larger mixing consoles, …

If one touches the metal housing of a Fresnel spot that happens to carry a dangerous voltage because of faulty insulation in the spotlight itself or in one of the cables, then this is a clear case of indirect contact: it is not at all normal or to be expected that a dangerous voltage is present there.

Protection against the risks of indirect contact (fault protection) can be achieved by means of

- grounding
- equipotential bonding
- residual current devices (RCD's)

- In some cases, the protection consists of special, double and reinforced insulation methods.

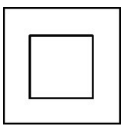
Insulation classes

The insulation of an appliance is a first indicator of how well the equipment is protected against direct and indirect contact. Insulation of equipment can be divided into several insulation classes, called Appliance Classes. These are defined in IEC 61140, and are included in the electrical safety regulations of most countries:

Class 0: Equipment that **only has basic insulation**, and provides no protective earth connection. Basic insulation consists of just one thin isolation layer, usually only just enough to make normal operation possible at all. Class 0 equipment is **not allowed on the market anymore** in most countries, but you can be confronted with it, for instance in older appliances that people want to use on stage for decorative reasons. In such cases, the risk should be eliminated by refurbishing the appliance until a higher insulation class is reached.

Class I: Equipment that only has **basic insulation**, but does provide a **Protective Earth (PE)** connection of its reachable conductive parts. This means these parts are **grounded** by a (usually green and yellow coloured) conductor to the earth. This will normally limit the voltage between the earth and the conductive parts to a safe value. Most conventional theatre fixtures like PC's, Fresnels and alike are examples of Class I appliances. But please note that the PE conductor can become a source of risk itself when it is unreliable, i.e. when it gets loose and connects to a live conductor.

Class II: Equipment that has a **double or reinforced insulation**, much stronger and far more reliable than basic insulation. This equipment should obligatory carry the double square symbol. It should **not be connected with a PE** conductor, since that would reintroduce the risk that has been eliminated by the double insulation. Portable electric tools (like drills) and most of the smaller appliances like CD, DVD, or multimedia players are examples of Class II appliances.



Pic. 7.3.1double insulation

Class III: Equipment that is **not directly connected to mains voltage**, but to SELV (Safety Extra Low Voltage). This is a voltage that is low enough to be safe when touched for indefinite duration, and is provided by a safe source like a battery or a safety transformer. Also, the mass or any of the conductors of this equipment should not be connected to the earth, or to the mass of any other equipment. The power to the Class III device can be delivered by a power supply that is itself a Class I or Class II device, provided that the low voltage part is separated from the mains by an insulation equivalent to Class II insulation (double or reinforced). Most smaller appliances that are powered by a power adapter (like laptops or smartphones) or by batteries (like a flashlight) are examples of Class III appliances.

International Protection rating (IP)

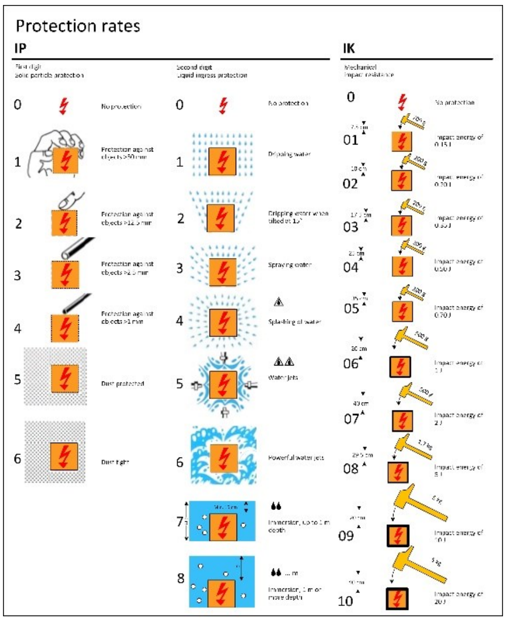
Protection against direct contact and against some other hazards, like short circuit, requires avoiding that objects, people (with a body part like a hand or a finger), dirt, or water can penetrate the equipment and reach live conductors. Additionally, we should also have some indication about which mechanical impact the material will resist without getting damaged. This is necessary if we want to be able to choose the right material for the application, and take the circumstances into account. The IP and IK rating of equipment gives us this kind of information.

The IP rating consists of the letters IP, followed by two digits. For example: a CEE plug might have rating IP44, which can be enough for normal indoor use. For outdoor use in a festival setting, we would rather choose one with an IP67 rating.

The first digit indicates the protections against penetration of objects, and can range from 0 (completely open, no protection at all) to 6 (completely dust tight). In between are the other protection levels, like protection against penetration of objects larger than 12.5mm (a finger for example, protection level 2), larger than 1mm (most wires, protection level 4) and so on.

The second digit indicates protection against penetration of water. It can range from 0 (completely open to water, no protection at all) to 8 (suitable for continuous immersion). Levels in between include 4 (splashing of water from any directions), 5 (water jets) and so on.

To this IP rating, a separate **IK code** may be added, to indicate the protection against mechanical impact (by being hit or by falling) without any damage. It consists of the letters IK followed by two digits, ranging from 00 to 10. The highest level denotes resistance against the impact of a 5kg hammer from a height of 40cm.



Pic. 7.3.2 overview protection rates

Earthing

As explained above, the conductive housing (mass) of Class I appliances should be connected to the earth using the green-and-yellow conductors of a grounding system. When an **insulation fault** occurs, this means that the insulation between the mass and the live parts or live conductors has a resistance that has become too low (order of magnitude less than a mega ohm for example). This is usually a consequence of damage or some other unwanted situation, like moisture or dirt. Without a PE conductor, the resulting fault current would flow entirely through the body of someone touching the mass. But the PE connection provides **a path with far lower resistance than the human body,** so most of this current is redirected through the grounding system, leaving only a small amount of current flowing through the body.

The **resistance of the grounding system** should be sufficiently low to get a safe situation. The voltage difference between the ground and the masses of the equipment should become low enough. This can be difficult to achieve, especially when the fault current is rather high: i.e. when a live conductor is in direct connection with the mass. At very high fault currents, the circuit breaker will open, but this may not be quickly enough to protect someone against a dangerous electric shock.

The continuity, the proper connection of the protective earth conductors, should be **periodically inspected**, both in the appliances themselves, as in any mobile parts like extension cords. When a current carrying conductor gets disconnected, it will usually be noticed rather quickly, because the equipment will not work anymore. But when a PE conductor is broken, this can remain unnoticed for a long time, until an accident or near accident happens.

Disconnecting an earth wire in the electrical system, for example to solve sound issues, is a very dangerous action. Not only do we remove part of the safety precautions for a group of appliances, we also create a more dangerous situation. If in one of the appliances a connection between a live wire and the earth would occur, all the housings of the other appliances that are connected will be under voltage.

Residual Current Device (RCD).

The aim of a residual current device or RCD is to make sure that power is quickly disconnected in the event of an insulation fault. Instead of relying on a circuit breaker that only disconnects at a fairly high current value, the RCD will detect if there is an important difference between the current flowing into the circuit and the current that returns from it. If this is the case, this probably means that part of the current is returning by the PE conductors or directly to the earth, instead of by the normal way. In this case the RCD will disconnect power.

Pic. 7.3.3 RDC

An RDC can already detect and switch off at low fault currents: less than 300mA (RCD with normal sensitivity) or even 30mA (RCD with high sensitivity). The exact requirements for sensitivities can vary from country to country. Usually, situations with additional risk factors like the presence of water or an outdoor situation will demand a higher sensitivity of the RCD.

An RCD can also detect and switch off a fault current in the absence of a Protective Earthing System. But in that case, it cannot reliably avoid that a person is exposed to a dangerous voltage for too long. That remains the role of a PE system, even when an RCD is provided as well. **An RCD does not replace the earthing system**. Although it can also trip without an earthing system, the RDC has to work together with it to create a safe situation.

Remember that both earthing and RCD's only protect in cases of indirect contact, not in cases of direct contact. The latter should be avoided by other means, like proper insulation. A very sensitive RCD can be added as an extra measure to this, but is not sufficient by itself for protection against direct contact. If I put my fingers into an outlet, an RCD will not protect me, since it can't detect the difference with a normal load to the circuit.

Equipotential bonds.

In most stage and event situations, there is a considerable risk that touchable metal or conductive construction parts like audience seating, metal parts of a stage or scaffolding, water or gas tubes, and alike could carry a dangerously high voltage. Normally the PE conductors of the appliances should prevent this. But they are not infallible: for instance, there is still a minor chance that they get disconnected, become crushed or cut off, or that insulation between live conductors and these metal construction parts gets damaged in some way. Because in those cases large amounts of people would be in danger at once, some other extra measures need to be taken.

Equipotential bonding involves the connection to the earth of these metal construction parts by a separate green-and-yellow conductor, independent of the normal PE conductors. Detailed regulations for this conductor can vary from country to country, but usually:

The equipotential bonding should connect **to the PE bar of a fuse box or another reliable upstream part** of the PE system. For instance, simply using the PE conductor of a nearby outlet or extension cord is not enough, since these depend too much on the normal PE conductor: if those get damaged, chances are too big that the equipotential conductor will be damaged at once as well. Additional grounding electrodes (separated from the main PE system) are usually not allowed either, since ground currents can cause dangerous voltage differences between both earth connections.

The equipotential bonding wires should follow a way **independent of the normal PE connections**, and can't run together in the same cable or tube with live conductors. They should have a **specific minimum gauge**, both for reasons of sufficiently low electrical resistance, and enough mechanical strength.

Disconnection of the equipotential bond of one part should **not cause disconnection** of other parts: the equipotential conductor should run as an undivided whole without any connections as much as possible. Equipotential bonds should be permanent in the sense that they are not passing through switches or plugs, but they can only be disconnected with tools.

Even when main equipotential bonds are installed, fault currents flowing through less than ideal conductors can still produce dangerous voltage differences between parts that can be touched at the same time by a person. For this reason, **additional equipotential bonds are necessary between parts** that are close enough to be touched simultaneously: these are direct connections between those parts, also with green-and-yellow wires.

Protection against overload and short-circuit

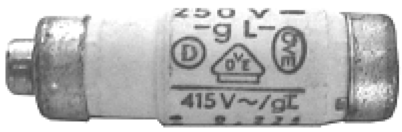
Overload is a situation where too much current is flowing through conductors because a load or several loads are connected that demand too much power. This is usually the result of a human error (miscalculation or underestimated loads). The amount of overload current is determined by the properties of the load or loads.

A short-circuit is a situation where conductors are connected directly to each other (without any load involved) in an unexpected and inappropriate way, and an extremely high current is flowing. This is usually a result of an incident or accident, like damaged cables or equipment.

The main prevention measure against the risks of overload and short circuit lies in the design of the electrical installation. It works in such a way that when a current becomes too large in relation to the properties of the conductor (mainly the section surface), it is switched off quickly enough to avoid the danger. This means that each circuit should be protected by an appropriate fuse or circuit breaker.

Fuses and breakers have a defined **nominal current** or **design current**: this is the maximum current that can flow through them for an indefinite time, and it is normally clearly indicated on the device. A second property that defines the breaker is the maximum short-circuit current. This value defines if the breaker is able to disconnect the maximum possible overload or short circuit current for that circuit (which is way higher than the nominal current) in a safe way. This means that fuses or breakers intended for smaller installations (like residential circuits) are not always appropriate for use in larger installations.

Fuses are relatively simple devices, consisting of a melting wire in an isolated housing. The principle is simple, the wire in the fuse is the weakest point in the circuit and will melt when the circuit is overloaded or when a short circuit occurs. Fuses come in several sizes, nominal currents, breaking currents and reaction speeds. When a fuse is blown, it should be replaced by a type that is the exact equivalent of all of these properties.

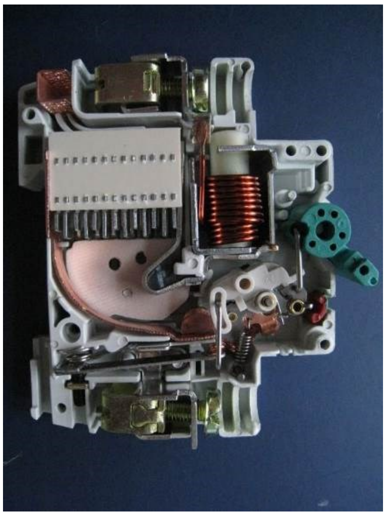


Pic. 7.3.4 fuse

Breakers also come in various types. Unlike fuses, they can be reused after tripping. Usually they have two working principles: one that deals with overload, and one for handling short-circuits.

A **condition of overload** is managed by a **thermal protection** device (or an electronic simulation of thermal protection). A mechanism with a bi-metal component will become hot and disconnect the overload when it lasts too long. Not all overload situations are switched off immediately, because that would cause problems with loads that cause an inrush current at start up (like lamps and motors). How long it takes to trip depends on the amount of overload and on the properties of the breaker. Reaction times can vary between a tenth of a second and up to an hour or more in some cases.

A **short-circuit condition** means that a far greater current is flowing, and it should be disconnected without any delay. A thermal protection would be too slow, that's why this condition is managed by a fast acting **electromechanical device**. It consists of an electro magnet which will disconnect the circuit as quickly as possible. **Reaction times** are as fast as a few milliseconds (ms).



Pic. 7.3.5 breaker

When a breaker is hot shortly after being tripped, you can be quite sure that overload is the issue. When it is not hot, it could be a short-circuit, a rather large overload (breaker did not warm up for a very long time), or it is a larger breaker that acts electronically instead of thermally.

Avoiding or reducing arc flash risks

The risk for an arc flash occurs more than you would expect in theatre and event situations. Where possible, we will avoid the possibility of an arc flash occurring. If this is not possible, we will try to reduce the effect. In contrast with the risks above, arc flash will mainly be avoided by good practice and less by technical interventions or appliances.

Avoiding the risk for an arc flash

Do not switch larger currents on or off when there is no important reason to do so. For example: before pulling the 125A CEE plug of your lighting system, or before switching a larger breaker on or off, at least first bring all dimmer channels down to zero, and switch off any other larger sub circuits.

In general, **don't work on or nearby non-insulated electrical circuits or equipment with power switched on**. Follow appropriate procedures to guarantee that power is indeed switched off and will stay turned off during the job. Be aware of other nearby parts or circuits that could still be under voltage.

Reducing the effect of an arc flash

Only when there are special reasons why you can't avoid working under voltage (like when you have to perform measurements or some specific types of trouble shooting), when you are **qualified** to do so and when **additional safety precautions** have been taken, it can exceptionally be justified to work under voltage. When working under voltage is unavoidable, **take the necessary precautions to reduce the risk:**

- At least wear **hand, arm, and eye protection**. For larger arc flash risks, a higher level of protection can be necessary: **face protection**, or even a helmet with neck protection, and complete arc flash resistant clothing (nomex or leather). Please note that simple working or isolating gloves do not always protect against arc flashes as well, unless they are specifically meant to do so.
- **Use appropriate, well-isolated tools**: not only screwdrivers and cutters, but also spanners and wrenches that are specifically designed to avoid short circuits.
- Avoid laying down tools or other objects where they can move or fall.
- **Use appropriate measuring equipment**. Avoid equipment that can measure currents by connecting leads: when these are used wrongly, a short circuit will occur. Please note that some cheap meters do not even have a built-in fuse for all measuring ranges! Use a device with a current clamp, or one that cannot measure currents at all. Even equipment that can only measure voltages can still constitute a risk when it is damaged by unexpected high voltage spikes: use a meter with the appropriate IEC category for the job. If possible, do not hold the meter in your hand when performing the measurement, but rather lay it down, or hang it in a safe position.

What you need to remember

The most important electrical risks are **electric shock, the effects of overload and short circuits and arc flash.** We tackle these risks using proper methods, adapted equipment and sensitive safety devices.

The main prevention measure against electrical shock lies in **switching off mains voltage.**

Direct contact means that somebody touches electric parts that can normally carry a voltage.

Indirect contact means that somebody touches a conductive part that normally should not carry a voltage, but does so now, because of an insulation fault or other cause.

The **Appliance Class** describes how well the equipment is protected against direct and indirect contact.

The **IP rating** defines if objects, people, dirt, or water can penetrate the equipment and reach live conductors.

The **IK code** indicates the protection against mechanical impact.

The **earthing** connects the conductive housing to the earth to avoid a fault current flowing entirely through the body of someone touching the housing.

A **Residual Current Device or RCD** makes sure that power is quickly disconnected in the event of an insulation fault.

Equipotential bonds connect metal structures to the earth to avoid the structures carrying a dangerous voltage.

Fuses and breakers protect against overload and short circuit.

The risk for **arc flash** is avoided by good practice.

- Don't switch larger currents on or off.
- Don't unplug active loaded plugs.
- Don't work on or nearby electrical circuits or equipment with power switched on.
- Use appropriate measuring equipment.

Terms and definitions

- electrical risk
- electric shock
- overload
- short circuits
- arc flash
- safety device
- direct contact
- indirect contact
- insulation fault
- appliance Class
- IP rating
- IK code
- mechanical impact
- earthing
- conductive housing
- the earth
- fault current
- residual current device (RCD)
- equipotential bond
- fuses
- breakers
- measuring equipment

- .

Rehearsal questions

07.03.01 True/False

- Protection against indirect contact is done by proper insulation.

07.03.02 Equipotential bonding is an example of protection against

a) direct contact.
b) indirect contact.
c) influence of water.

07.03.03 Class II: Equipment that has a double or reinforced insulation should

a) be connected to the earth.
b) not be connected to the earth.
c) Doesn't matter

07.03.04 True/False

- The IK rating gives information about the mechanical strength of a housing.

07.03.05 The last digit of an IP code gives information about

a) penetration of objects.
b) mechanical strength.
c) penetration of water.

07.03.06 An Earth (PE) connection provides a path with

a) far lower resistance than the human body.
b) a higher resistance than the human body.
c) the same resistance than the human body.

07.03.07 True/False

- The best way to solve a hum in the sound system is disconnecting the earth wires.

07.03.08 The value of the fault current of a residual current device or RCD is expressed in

a) mA
b) kV
c) A

07.03.09 True/False

- An RCD does not replace the earthing system.

07.03.10 Equipotential bonds connect metal structures

a) to the earth.
b) to each other.
c) Both

07.03.11 Equipotential bonds should be connected to

a) the earth wire of a plug.
b) a separate earth pen in the ground.
c) a main PE bar.

07.03.12 A short circuit is a situation where

a) too much power is transported through a wire.
b) two conductors are connected to each other without any load.
c) a wire is cut and sparks between the ends of the cut.

07.03.13 True/False

- A breaker of 10A will trip immediately when the current is 10.5 A.

07.03.14 an arc flash cannot occur when

a) a load is switched off.
b) a load is plugged in.
c) the installation is not powered.

7.4 Cables and connections

At the end of this block, you

- Understand the different properties of cables and plugs
- Are able to identify equipment and material

A large part of our job is "pulling" and connecting cables. To work safe, you have to be able to identify cables, check if they fit the purpose, if they have the right plugs and connectors, and if they are adapted to the power we need to transport and the circumstances they are used in.

Strictly speaking, we use extension cords rather than cables in mobile electrical systems. A cable is a bound or sheathed group of mutually insulated solid copper conductors. An extension cord is made of flexible stranded conductors and is suitable for mobile, temporary use. But because in the sector the word **cable** is frequently used, we will consistently use the word cable here.

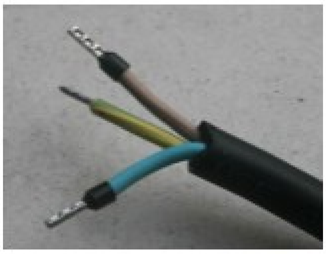
Cables are rather universal, but plugs are less standardised. In this part, we will discuss the common plugs and give an indication of what is used in different countries.

Properties of cables

There are hundreds of different types of cables, all adapted to a specific use or specific circumstances. To be able to choose the proper cable, we need to know something about the specific properties of cables.

Within our sector we mainly use cables with multiple insulated conductors. Each conductor is made of very thin stranded copper wires. This is necessary for flexibility, because a solid conductor would break after several bends. The conductors are held together with a protective layer that insulates and provides mechanical strength.

But stranded conductors have disadvantages too. Sharp bends can damage the cable. Therefore you should **never make knots in cables**. Apart from this, the connection of the thin loose wires in a plug is less secure. Therefore you always need to use **ferrules** to connect a stranded wire in a plug.



Pic. 7.4.1 ferrule on stranded wire

The **section** of the conductor is expressed in square mm. This section determines how much current can pass through the conductor. The sections of conductors are standardized and the following sections exist:

0,75 / 1 / 1,5 / 2,5 / 4 / 6 / 10 / 16 / 25 / 35 / 50 / 70 / 95 / 120 / 150 / 185 / 240

The **amount of conductors** depends on the foreseen use of the cable. Power cables in theatre or events will have 3 conductors for monophasic use, 5 for three phase use and up to 25 for multicores.

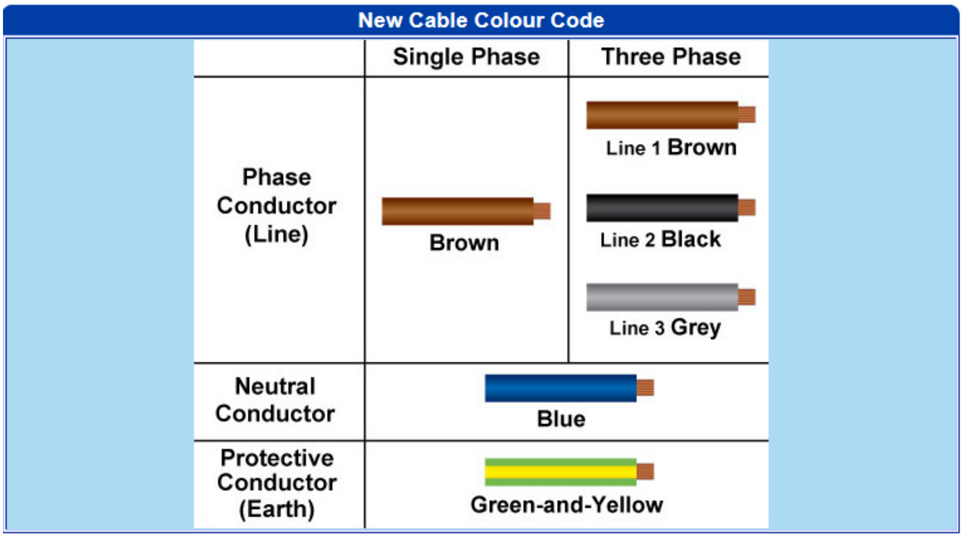
Cables with a limited amount of conductors use a **colour code** to identify the different conductors. In Europe the IEC_60446 codes, defined by the European Committee for Electro-technical

Standardization (CENELEC) is used. For multicores, with many conductors, a numbering system is used.

The earth conductor is always green and yellow.

The neutral conductor is always blue.

Remember that the colour code is no guarantee that the connection is right! It is always possible that someone made a mistake when making the connections!



Dia 7.4.1CENELEC colour code

The material of the outer cover and of the insulation cover of the individual wires largely defines under what circumstances a cable can be used. The material defines the insulation resistance, the flexibility, and the mechanical, thermal, and chemical resistance. In stage and event use, we mostly use rubber and sometimes also PVC covers.

The last property is the **diameter** of the cable itself. This diameter is important for practical issues like cable entries and cable glands in plugs.

Defining the wire section

To define the section of a cable, we need to know what power loss occurs in the cable. Even if copper is a good conductor, it still has a resistance that will provoke loss throughout the cable. The lost energy is converted in heat. This loss also means we will have a lower voltage at the end of the cable. In most countries, we accept a voltage loss of maximum 3%.

The resistance of a cable depends on 3 parameters:

- The length of the cable (lg, in meters, the longer, the more resistance)
- The section of the wires (A in mm2, the thicker, the less resistance)
- The resistivity (ρ (rho) in ohm meter, for copper 0.01785)

To calculate the resistance of a cable, you can use the following equation. It is called Pouillet's law, named after the French scientist Claude Pouillet.

$$Rg = \frac{2 \times lg \times \rho}{A}$$

The factor 2 in the formula originates from the double wire you need to incorporate. Based on the result, you can calculate the loss in the cable.

In reality, instead of calculating, we will use a table to define the section. The table will give you the standardised sections and the allowed maximum current for the section. The allowed current can vary depending on what type of protection device is being used.

Example from the Belgium AREI rules for electrical installations.

Cable sections and their protection (according AREA, BE)		
Section in mm²	Rated current of fuse (A)	Rated current of breaker (A)
1,5	10	16
2,5	16	20
4	20	32
6	32	50
10	50	63
16	63	80
25	80	100
35	100	125

Dia 7.4.2 ARAE wire sections

Both the table and the calculation start from the assumption that the cable is used under normal circumstances. In stage and event use, we may need to implement higher demands. For example extreme lengths, the lack of cooling caused by bundling cables, and a higher environmental temperature working outside or near spotlights will influence the result.

For **multi core** cables, this means that we only can use 80% of the total allowed current. Each pair of wires can conduct the maximum current, but the total current should be limited because of the heating of the cable.

Types of cables

Pic. 7.4.2 Rubber insulation

The most common cables in stage use are rubber cables. Within this category there are different types available.

For lighter work, CTLB (HO5RRF and H05RNF) cable is often used. This is a flexible cable with **rubber insulation**. Such cords usually have an imprint that, in addition to the cable type, also indicates the number of conductors and their section: e.g. 3G6 (3 conductors of 6mm2), 5G16 (5 conductors of 16mm2).

Pic. 7.4.3 Neoprene insulation

For the heavy-duty work, CTMBN and CTFBN (H07RN-F) neoprene cables are used. Neoprene is a synthetic rubber type. With these cables, both wires and cover are extra insulated. They can be used in difficult circumstances (festivals, outdoors, etc.).

Next to rubber cables, there are still PVC cables in use in theatre or event activities. VTMB-cable is frequently used in prefabricated cables with moulded plugs. PVC is more rigid and less flexible, this sometimes makes the result of cabling a bit messy.

We set very high standards for the flexibility and mechanical resistance of multicores. Besides neoprene cables, we also use cables of the type öl-flex or multiflex. These cables, made for industrial applications where the cables move permanently, like robot arms or wind mills, are very suitable for the intensive use in the event and theatre sector.

Pic. 7.4.4 multicore

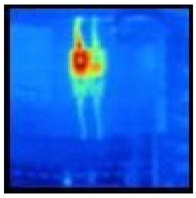
Connectors

Up until now, we have only looked at the cable itself. Without a plug, however, a flexible cable is not very useful. In the next part, we discuss the different types of connectors used in theatre and event technology.

Properties of connectors

The **maximum allowed voltage** of a plug is determined by the insulation value of the enveloping material. The higher the voltage, the better the envelope has to be isolated.

The **maximum allowed current** in a plug is determined by the pins. Of course, like the cables, the thickness of the pins is important. This determines the resistance of the conductive parts. The **contact resistance** between the pens of the plug and the busses of the socket is even more critical. The power must "jump" from the bus to the pen.



Pic. 7.4.5 Thermographic picture of a overheated contact

The contact resistance is determined by the surface material. Therefore some pens are silver plated or even gilded. In addition, a good clamping of the bus around the pen causes a maximum connection between both surfaces. This also explains why plugs with burned pins or, for example, sand or dust between the pins form a risk. They must be replaced immediately, as the resistance of the transition increases. This causes the connection to overheat and in some cases even become welded together.

Pic. 7.4.6 Melted connector

The **number of contacts** is determined by the intended use. For a three-phase connection with zero and earth, you need 5 connections, while you have enough with 3 connections for a single-phase grounded connection.

Of course, the way the **earth connection** is worked out in a plug is important. It is key that the connection of the earth must be established before the other pins connect. This ensures that your device is connected to the earth before it is powered. Therefore, the earth pen is usually longer than the other pins in a plug. This is called a "first mate, last break contact": it will be the first to connect and the final one to disconnect.

The reverse of this kind of contact is the **pilot contact** of a CEE plug. This is a "last mate, first break contact". It will only connect when all other pins are connected. The purpose of this is to avoid burning the pens and sparking between the pens and the busses. This power plug is only switched on when all the contacts are made.

The **earth of the plug housing** is a critical point for many plugs. If a plug has metal parts that you can touch from the outside, these metal parts should of course be earthed. The risk of a loose wire touching the casing is not imaginary.

A good **strain relief** ensures that the cover of the cable is clamped in the plug so that no forces are applied on the individual wires or connections. The strain relief must clamp the cable completely.

Some plugs have a **protection against unwanted disconnection**. This security can take many different shapes. CEE power connectors and Socapex connectors have a cable gland that can be tightened. Smaller CEEs usually have a pen on the lid that has to hold the plug. Harting connectors work with clips, while PowerCon connectors are equipped with a bayonet system with a security.

A plug is subject to mechanical and environmental influences. It will sometimes fall, swipe against a wall or will be used outdoors or near water. The **mechanical resistance** is expressed in the IK code. The **environmental protection** is expressed in the IP code.

On some plugs you will find dozens of **certification marks**. These indicate compliance with a **national standard**. Some examples of standards are CEBEC (Belgium), VDE (Germany) and KEMA (Netherlands). In the European Union, member states acknowledge reciprocal certification marks.

Pic. 7.4.7 VDE certification mark

Pic. 7.4.8 KEMA keur certification mark

Pic. 7.4.9 CEBEC certification mark

Usually you will also find a **CE marking** on the plug. This is not a quality mark in the strict sense, but an indication that the manufacturer complies with all European rules.

Pic. 7.4.10 CE marking

Finally, a plug must meet certain standards. A standard is an agreement between different users to use similar material to make it possible to exchange equipment. This might as well be a standard within a country, a sector or even within a single theatre house.

Types of connectors

We will first discuss the plug types used internationally. After that, we will briefly discuss some national standard plugs. Finally, we will go over the most common multi-cables and the single-wire plugs.

The CEE Plugs of the P17 type represent a wide range of different plugs. They are used for different voltages, currents and power grids. We only discuss those plugs that are often being used on the stage.

Pic. 7.4.11 CEE P17 plugs

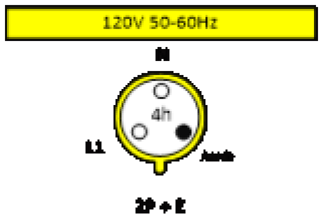
The size of the plug indicates the **maximum current** the plug can be used for. Plugs exist for 16A, 32A, 63A, and 125A.

The colour of the plug indicates the **highest voltage allowed**. For a red plug this is 415V, for a blue one 240V and for a yellow one 120V. In stage applications, purple plugs are sometimes used for voltages up to 48V. However, you must be aware that the colour only indicates the highest allowed voltage. It is perfectly allowed to use a plug for a lower voltage. For stage applications, where fuse boxes and dimmers can be switched on and off, it is not uncommon to use red plugs in a three phase delta grid (3 x 230V).

The **position of the earth pen** in relation to the major keyway guarantees that one type of plug can't be connected to another type of socket. This position is expressed by the "hour position" of the earth pen, when the major keyway points downwards. The major keyway is a projection on the plug shroud, which aligns with a notch on the socket. In other words, when the keyway points downwards, and the earth connection is at 4 o clock in the circle, the plug will be marked 4h. This fits a yellow single phase connector.

The plugs are built in such a way that the **earth pen always makes contact first**. This is done to ensure the appliance is connected to the earth before it is connected to the power.

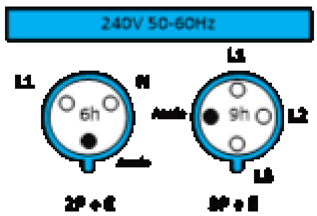
Yellow plugs are only used for 120V. In the stage practice, they are for example used to connect two aircraft fourbars or to connect two 120V PAR lights in series to a 230V connection.



Dia 7.4.3 Yellow CEE plug

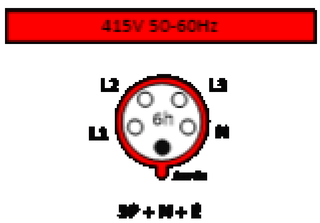
There are two versions of **blue plugs** that are often used. The monophasic plugs are used for connecting devices and spots.

The three-phase version is used in older installations, with a delta grid 3 x 220V.



Dia 7.4.4 Blue CEE plugs

The most commonly used **red plug** is the three-phase plug with neutral. This is used in a grid with a maximum voltage of 400V.



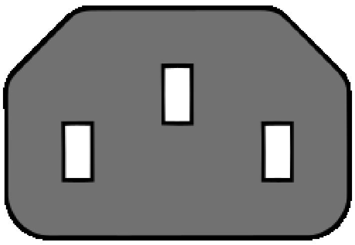
Dia 7.4.5 Red CEE plug

The **CEE 22 device plug** (also referred to as the Euroconnector) is a plug that is intended primarily for appliance inlets. In the stage practice, such plugs are also used for patch systems. The plug is equipped for a current of 10A, but it is recommended to only charge it to 6A. There are different variations on this plug, with different cut-outs. The cut-outs define the maximum working temperature.

Pic. 7.4.12 CEE 22 no notch

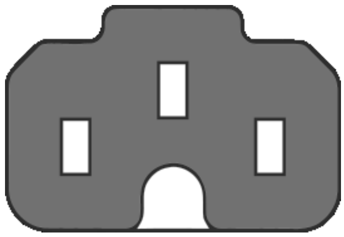
- No notch, maximum temperature: 60°
- One notch, maximum temperature: 120°
- One notch and one bulge, maximum temperature: 155°

Pic. 7.4.13 CEE 22 notch and bulge



Dia 7.4.8 CEE 22 no notch

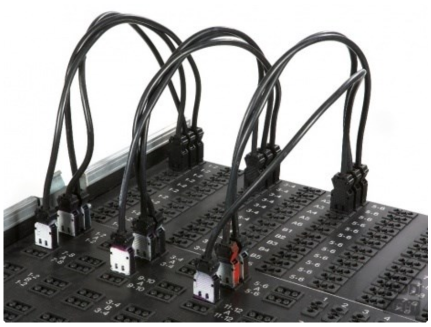
Dia 7.4.7 CEE 22 one notch



Dia 7.4.6 CEE 22 one notch and bulge

.Another plug that is often used for patch purposes is the **Wieland connector**. This is a very compact 20A plug.

Pic. 7.4.14 Wieland connector



Pic. 7.4.15 Patch

In Belgium and France, plugs with a pen earth, the **E-type plug**, are used in household application and on stage. The sockets of this E-type have a (male) earth pen that fits the hole of the plug.

Pic. 7.4.16 E-type socket

In Germany, the Netherlands and Sweden, the **F-type socket** is used. The plugs are also called "**schuko's**" an abbreviation of the German word "Schutzkontakt" which means earth contact. The F-type socket has receptors for the earth clips on both sides.

Pic. 7.4.18 Shucko

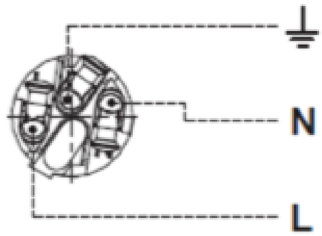
Pic. 7.4.17 F-type socket

Of course, also E and F type plugs exist, but mostly the **hybrid CEE 7/7** type plug is used, that has both pen earth and side earth clips. The plug fits the E-type as well as the F-type (shucko) sockets and can be used in many countries.

Pic. 7.4.19 CEE 7/7 plug

Other European countries, even if there is an evolution towards a common standard, still have different types of connectors with specific properties. For example, in some countries there are different (and incompatible) connectors for 6A, 10A, 13A, etc. Some have flat pens, other round pens. Some have fuses in the plugs. Outside Europe, the differences are even more extreme. If you prepare for a tour around the world, you need to make sure you have all the different adaptors needed.

The **PowerCon** connector is a rather recent monophasic plug. It is developed as an appliance inlet. The plug has a locking devise. It is very compact and can, compared to its size, handle large currents. There are versions for 20 A and 32 A



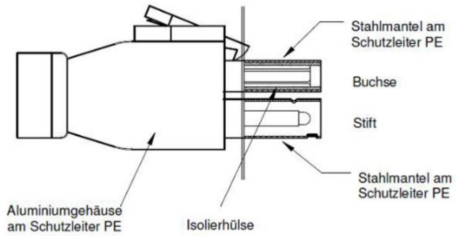
Pic. 7.4.22 PowerCon pen configuration

Pic. 7.4.20 PowerCon

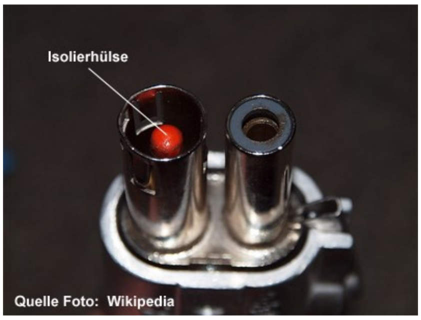
PowerCON TRUE is the robust outdoor version, it is a 16 A single phase mains connector with breaking capacity and a protection of IP65.

Pic. 7.4.21 PowerCON TRUE

On stage in Germany, the **EBERL plug** is used for lighting applications. This is a unisex, monophasic plug for 250 V and 63 A. As it is unisex, a cable can be used in both directions.



Pic. 7.4.25 EBERL plug configuration



Pic. 7.4.24 EBERL plug

Pic. 7.4.23 EBERL cable

Newer installations in Germany are fitted with the **BühnenStecker (DBS)**, a plug system developed specifically for lighting purposes. The plugs come in different power ratings, indicated with different colours.

- Black / Blue 3 kW
- Red 6 kW
- Green 12 kW

Pic. 7.4.26 BühnenStecker Male

Pic. 7.4.27 BühnenStecker Female

Multicable

Multicables are used to connect multiple circuits with one connection action. The two most commonly used types are the Harting connector and the Socapex connector.

Pic. 7.4.28 Harting connector

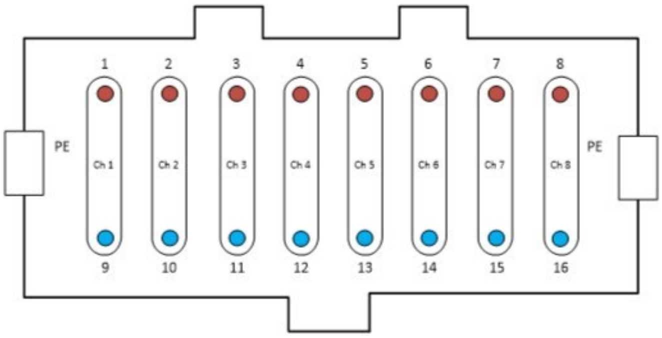
Harting

The most used **Harting connector** for the lighting applications is the sixteen-pole connector. It is commonly called a multi 8, which refers to the 8 pairs that can drive 8 circuits. Harting is a brand name, there are also other manufacturers, such as Wieland, who produce this plug.

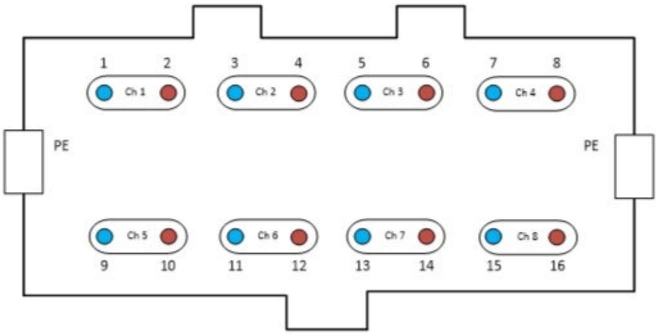
To ensure a good and reliable connection, the connectors must be secured with **clips**. These clips can be on the male as well as on the female part. This often causes a problem, as it happens that there is a clip on neither or both sides. Some companies choose to put the clips on end parts only (dimmers, multiblocks,...) because this gives the smallest chance for damage. In that case, clips will not be mounted on the cables, which causes a problem when extending a cable. This is usually solved with the help of fasteners, like tape or T-fix.

This plug is contains 16 contacts. The **earthing** has a specific contact, which is separate from the sixteen connection points.

There is no standard for the pen configuration. Two connection schemes are used:



Dia 7.4.9 Traditional harting configuration



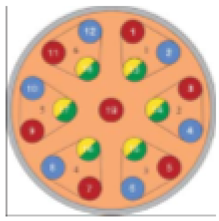
Dia 7.4.10 NOB pen configuration Harting

In any case, you need to look out when material is hired or when you want to connect to a fixed installation. The cables are usually interchangeable, but the adaptors to single circuits and the internal connections (dimmers etc.) are not.

Socapex

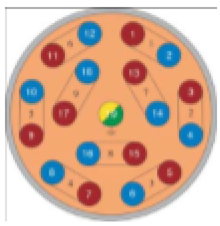
An alternative to the Harting connector is the **Socapex connector**. This 19-pens connector is a round plug with a gland, which is a highly reliable and mechanical connection.

Also in this case are there different **pen configurations** possible. The choice between the schedules depends on local legislation. In some countries, a **separate earth** must be provided for each pair. In that case, the first scheme will be used. Due to the need for more pins for the earth, the number of channels is limited to 6.



Dia 7.4.11 Socapex separate earth configuration

When a **common earth** is allowed you can use this plug with 9 channels. Look out that the different standards don't get mixed. Otherwise, the earth can be connected to a power carrying line.



Dia 7.4.12 Socapex common earth configuration

Litton

Some countries use alternative connectors for similar purposes. In Sweden for example the Litton plug KPT Series 18-32 is used for 8 channel multicables. This is a military graded plug that is also used in railway applications.

Pic. 7.4.29 Litton plug

Powerlock

For currents over 125A it becomes difficult to use multi-conductor cables. The cables become difficult to handle and to coil. For this reason, such currents are connected with **single wires** (for Earth, N, L1, L2 and L3), which are connected by separate plugs.

The **Powerlock plugs** exist in a 400A and a 600A version and for sections up to 300mm2. The Powerlock plugs are built in such a way that you cannot touch any parts under tension with your fingers. In addition, the plugs for different lines are **not interchangeable** and cannot be connected wrongly by mistake. There are even connection boards that ensure that the connections are made in the **correct order** (earth, ground, phase). Finally, at the European level, **colours** have been standardized, so that no mistakes can be made.

Pic. 7.4.30 Powerlock plugs

What you need to remember

The main properties of a cable are:

- section of the conductor
- amount of conductors
- The material of the outer cover
- diameter of the cable

The earth conductor is always green and yellow.

The neutral conductor is always blue.

The main properties of plugs are:

- maximum allowed voltage
- maximum allowed current
- number of contacts
- the way the earth of the plug housing is constructed
- quality of strain relief
- protection against unwanted disconnection

For CEE plugs

- The colour indicates the highest allowed voltage
- The size indicates the highest allowed current
- The position of the earth against the keyway is described in hours (h)

Type E connectors have a pen earth

Type F connectors (shucko) have a clips earth on the sides

A CEE 7/7 type plug fits E and F type outlets

Most important types of multiconnectors are

- Harting
- Socapex
- Multicables can have different pen configurations

Terms and definitions

- solid conductors
- cable
- stranded conductor
- ferrules
- section
- colour code
- cable entries
- cable gland
- resistivity
- Pouillet's law
- neoprene
- PVC
- maximum allowed voltage
- maximum allowed current
- contact resistance
- earth connection
- pilot contact
- last mate, first break contact
- first mate, last break contact
- strain relief
- protection against unwanted disconnection
- bayonet
- mechanical resistance
- certification marks
- CE marking
- CEE P17 Plug
- major keyway
- CEE 22 device plug
- maximum working temperature
- patch
- earth pen
- earth clips
- unisex
- BühnenStecker (DBS)
- CEE 7/7
- E-type plug
- F-type plug
- multicable
- Harting connector
- Socapex connector
- pen configuration
- Litton plug
- Powerlock

Rehearsal questions

07.04.01 True/False

- A stranded wire is a solid copper wire.

07.04.02 The wires of a stranded wire are kept together by a

a) jacket.
b) ferrid.
c) ferrule.

07.04.03 The section of the conductor defines

a) the amount of phases.
b) the maximum amount of voltage.
c) the maximum amount of current.

07.04.04 Connect

a) A blue
b) B brown
c) C yellow-green

1. earth
2. neutral
3. phase

07.04.05 The diameter of the cable defines

a) the cable gland.
b) the maximum amount of voltage.
c) the maximum amount if current.

07.04.06 True/False

- The resistance of a cable depends on the length of the cable.

07.04.07 True/False

- The allowed current in a cable depends on the type of fuse used to protect the cable.

07.04.08 When a cable is used under circumstances that are heating the cable, we have to

a) limit the allowed current.
b) limit the allowed voltage.
c) decrease the section of the wires.

07.04.09 The strongest material for cables is

a) PVC.
b) neoprene.
c) rubber.

07.04.10 The maximum allowed voltage of a connector is limited by

a) the contact resistance of the pens.
b) the insulation of the housing.
c) the construction of the earth connection.

07.04.11 The maximum allowed current of a connector is limited by

a) the contact resistance of the pens.
b) the insulation of the housing.
c) the construction of the earth connection.

07.04.12 The earth connection of a plug should be

a) first mate, last break.
b) first break, last mate.
c) Doesn't matter

07.04.13 The strain relief of a plug is used to

a) keep the pens in place.
b) avoid tension on the connections of the pens.
c) avoid tension on the connection between plugs.

07.04.14 True/False

- Mechanical resistance is expressed in the IP code.

07.04.15 True/False

- A plug with a CEBEC certification mark can be used in Germany.

07.04.16 True/False

- A CE marking is an international certification mark.

07.04.17 The colour of a CEE P17 indicates

a) the voltage on the plug.
b) the highest voltage allowed on the plug.
c) the amount of phases available.

07.04.18 True/False

- The inscription 6h on a CEE P17 plug means you can only use it for 6h at a time.

07.04.19 True/False

- Blue CEE P17 plugs can only be used for monophasic connections

07.04.20 Connect

a) E-type
b) shucko
c) CEE 7/7


1


2

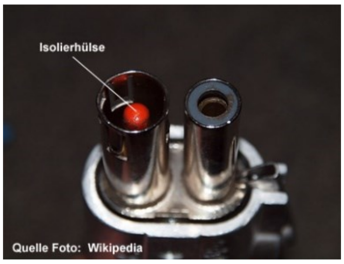

3

07.04.21 True/False

- When they are equipped with a Harting connector, you can connect any dimmer with any distribution box.

07.04.22 Connect

a) Harting
b) EBERL
c) Socapex




1 2 3

07.04.23 True / False

- A Socapex with separate earth can be used for 9 channels.

07.04.24 True / False

- All Powerlock plugs are interchangeable.

8 Work safely with tools

To Work safely with tools, you must:

Work safely with hand tools and commonly used powered hand tools, required for your work, according to manuals and instructions.

This means you master following skills:

- Uses the right tools for the job and material.
- Works according to the safety instructions.
- Ensures work environment is clean, clear and stable.
- Ensures materials are fixed securely.
- Prevents risks for yourself and environment.

You master following knowledge:

- Hand tools
- Powered Hand tools

You have following attitudes:

- Safety awareness
- Awareness of others' behaviour
- Awareness of your environment

In a theatre and event environment we work a lot with different tools, from simple hand tools to more complex and riskful electrical tools. We use them while preparing shows that are still in rehearsal, for maintenance and of course while setting up the show. Sometimes tools are even used in or during a performance.

Sometimes, these tools are used under normal circumstances, in an organised workshop, without stressing deadlines. But more often, we use tools in a **complex environment**, often not really adapted to the job, on location or in a temporary workshop and in limited working conditions. We work on last minute changes with strict deadlines, because doors open at 8 'o clock. We use tools on height, mainly for smaller jobs, mounting, adapting or repairing sets or equipment. We work together with colleagues that have other priorities or are doing something completely different than us.

Fig. 7.4.a Hamlet

In these chaotic, unpredictable circumstances, we have to be sure that we work safe, even in situations with a high workload or pressure. We have to be **aware of the dangers** and we have to take care of our own safety, the safety of colleagues, of the equipment and the environment.

In this text, we limit ourselves to hand tools and powered hand tools that are most commonly used in a theatre and event environment. The focus lies on tools to work on sets, performance equipment, etc.

- Hand tools are fairly simple tools that you use with your hands and which are usually not powered.

Hand tools are for example screwdrivers, hand saws, chisels, wrenches, etc.

- Powered hand tools are tools that move during operation or can be easily moved from one place to another while they are connected to the supply circuit.

Powered hand tools are for example a hand drill, a cordless screwdriver, a circular hand saw, a nail gun or a spray pistol.

Use proper tools for the job

If you want to do a proper job, you need the proper tools. This is not only a prerequisite for good and fast work, but especially for safety. **Selecting the right tool** for the respective application is the first step of safe use. Sometimes it costs a little bit more time to get the proper tools, but you will lose more time when you use the wrong tool and things go wrong.

A profound understanding of the application of tools and the properties of materials is essential. But even then, we have the **bad habit** to use what is at hand instead of getting the right stuff. This is not helpful to create a safe situation.

The right tool for the job

Every tool is made for a specific purpose. Engineers probably spend years giving the tool the properties needed for a specific activity, the conditions of use, the expected stresses, etc. These efforts only make sense if we use the tool as intended.

- Wrenches are not impact tools,
- Screwdrivers are not chisel tools,
- Hammers are not bending tools
- Pliers are not screwdrivers.

Using tools in the wrong way usually ends in personal injuries. Using tools for other purposes means we stress them in a way **not foreseen by the developer**. This will cause cracks, breaks, splinters shooting off, damage to material, unexpected behaviour,… These are all elements that increase the risk of an accident occurring.

Multi-tools are never right for the job

Multi-tools are made to fulfil multiple purposes, which means they are not really fit for any of them. Using the pliers to fasten bolds will damage the nuts and will damage the cutting surface of the tool. Using the (metal) multi-tool to work on electricity generates obvious risks. Handles that are used to hide other tools are not made in the most ergonomic way. These tools are fine for home or emergency purposes, where no other tools are available, but they **don't belong in a professional environment**.

Fig. 7.4.b Swiss knife

The right size

Tools or accessories that catch a bolt or a screw need to fit tight. The wrong size of bit or tip, the wrong size of wrench can damage a screw or a nut and decrease safety. The tool can slip and fall or even fly in your face.

Quality of tools

High quality tools will have less wear, less deformation, less breaking and less damage, especially during intensive use. Using high-quality tools will lead to a serious reduction of accidents. Of course, even the highest quality tools will only stay in good condition if they are treated and maintained carefully.

Cheap tools are often low-quality tools. They can cause accidents and have to be replaced sooner. In the long run, cheap tools are more expensive.

The proper tool for the material

It is not enough to choose the right tool for the job, the tool also needs to be **adapted to the material** you are working with. The hardness of the tool and the way the tool cuts in the material must fit the material you want to process.

- A steel hammer to slam aluminium pens will damage the aluminium
- A wood drill will break if used on steel
- A saw with big teeth will leave truncated cutting planes

The **sharpness** of cutting tools has to be adapted to the material. A dull tool will require more effort and result in sloppy work. But depending on the material you process, a tool that is sharp and therefore very thin, will damage or break faster, especially when used on the wrong material. For example, a wood chisel used on stone will be damaged in a second.

Fig. 7.4.c Wrench

The **hardness** of the tool has to be adapted to the material. Drilling through steel will ask for a harder drill than drilling plastics.

In some cases, **the previous use** of the tool is important too. Sawing aluminium leaves particles on the saw blades. If you later use the saw for steel, the aluminium particles will block the saw.

So a profound understanding of the materials you work with, including their properties and the way they are to be processed, is essential to choose the right tool. If you have doubts, ask an expert.

Proper accessories and consumables

A lot of tools come with exchangeable parts, usually this is the working part that cuts material like replaceable knife blades, drill bits, saw blades, or grinder disks or the part that has it in a grip like screw bits or sockets for bolts.

Pic. 7.4.1 different types of drills

The connection between the tool and the accessory will transfer all the necessary power. So the tool absolutely needs to fit exactly. **Bad connections** can damage the tool or cause the accessories to slip or to detach. Powered tools can get blocked by detaching accessories. Sometimes there are small variations between brands, making them unique for one type of powered tool. There is no room for experimentation here, especially with high speed rotating elements of powered tools that can fly away with the speed of a ninja throwing star, or even burst and explode.

Pic. 7.4.2 set accessories

Ergonomic design

Hand tools and powered hand tools imply using human force and especially hand and arm movements at a repetitive, high frequency. Short-term effects of these actions can be calluses, blisters, bruises, … Long-term effects include insensibility and loss of muscle strength in the case of overstressing tendons or nerves. This can lead to a severe more or less continuous pain.

These risks stress the importance of an **ergonomic design** of the tools. The tool must be designed to make it easy to use the necessary force, the handles should have a proper size, shaping, angular position and surface finish to get optimal grip. Despite the best ergonomic design, always take into account that repetitive movements can still be harmful.

Training

To be able to use tools in an appropriate way, you need to be trained. A lot of the instructions can be found in manuals. You need knowledge about the **use** of different tools, knowledge about the **properties of materials**, and you must be aware of **possible hazards** and the precautions to take. All this is part of good practice and craftsmanship expected in order to work safe.

Inspection and maintenance

Tools should be inspected visually before and after every use. Attention points are:

- Wear and tear
- Proper fit of handle, guards, accessories, …
- Cracks in the casings of double-insulated tools
- Sharpening
- Labels showing tools are within time limitation of legal testing.

Defective or unsafe tools are to be taken **out of service** immediately, tagged to avoid further use, reported to the person responsible for safety and repaired prior to further use.

On a regular basis, inspections are to be carried out according to the safety policy of the organisation and the legal requirements.

Maintain

To keep your tools in a good shape, they need to be maintained. You can either perform **preventive** maintenance in regular time intervals or **after an inspection** that showed deficiencies. Basic maintenance tasks can be done by yourself, but more complex tasks like regrinding tools are work for experts. Some basic principles of maintenance:

- Before cleaning and doing maintenance on machines, switch off and unplug the machines.
- Greasy, wet, slippery or dirty tools must be cleaned and dried.
- Tools need to be protected against rust and corrosion, especially when not used for a longer time (typical in theatre and events).
- Handgrips and safety accessories connections need to be tightened.

More complex maintenance tasks like sharpening or regrinding, setting the dimensions of screwdrivers or repairing tools is experts' work.

Store

Organising a good storage will increase efficiency and protect the equipment and the people working with it.

To protect equipment from damage (and theft)

Proper storage will keep the tools dry and protect them against corrosion and other damage. The storage can be locked against theft. A good organisation avoids loss. Missing tools are identified in the blink of an eye.

To protect people from hurting themselves

A good storage system avoids people getting hurt by unintentional contact with pointed and sharp tools. Chisels, knifes, cutting blades and screwdrivers that are not protected, can hurt colleagues searching in an unorganised toolbox. Electrical tools that are not switched off properly can cause even more damage.

To protect others

In some workplace/work environment the organization of the tools in especially designed toolboxes is an important part of the safety organization, i.e. for some work at height all tools must be back in their place in the tool box before any one is allowed back on stage.

To work more efficient

Tools are used in different places and they often kick around in the workplace after use. This makes it hard to find them back and causes the use of wrong tools because we can't find the right ones. A **well-organised storage** will solve this problem.

On location or on tour, a well-organised tool box or tool case on wheels isn't a luxury. Ideally, the tools are organised to help you blindly find what you need. You can take your case around with you, so you always have all your tools and accessories close to the spot where they are needed.

Machines often come in custom made cases. They are made for a specific machine and gather all the accessories needed. You see if something is missing right away.

In a workshop, tools can be hung on panels that show their shadows. This gives a nice visual overview of what you have. This can also be the place where the batteries are charged, in order to keep the tools ready for use.

Carrying tools

Tools provoke not only a risk when used. There are also risks involved when carrying or transporting them. Tools often have sharp sides and are generally rather small, heavy objects that can injure when dropped from a height. Some tips to prevent accidents:

- Secure pointed and sharp tools against unintentional contact.
- Use the protection provided with the tool. (plug-on caps or other holders)
- Close the tool to protect the sharp ends (like retractable cutter knifes).
- Do not store tools in the pockets of clothing, but use a special belt or a belt bag designed for this purpose.

- Do not grab for something in a bag with a lot of tools, this can cause puncture wounds or cuts.
- Ensure powered tools cannot be switched on.
- The power cable of a tool is not meant to carry or raise the tool. It is better to use a rope with a carabiner.

Working with tools

Hand tools are the oldest means of man's work. Despite the development of mechanized technology, they are still an indispensable help today. Despite construction, manufacturing and material improvements, every user should be aware of the possible risk of injury, even when dealing with the simplest hand tools.

Secure the material

A tool can only impact the material properly **if the material does not move**. And to use the tool with maximum impact you need to have both hands free. Holding the material with your hands or feet forces you to come close to the active part of the machine, the cutting edge, the rotating element,... Unexpected movement of the material can cause extra risks like the work piece flying away from the machine and hitting someone.

Securing the material you are working on is part of the safe and proper use of the tool. Clamping or fixing the material, especially small pieces, makes your work safer and also easier.

Ergonomic position

To keep full control over your tool, you need to stand in a comfortable and stable position. You need to be able to move freely and reach all controls without stretching too far or reaching over the tool. This guarantees that you are able to apply maximum force with minimum effort in a safe way. Ensure you have a **good grip** on the tool. Your hands must be kept free of oil and grease while using tools.

Where possible and applicable, use a workbench that is adapted to the work and your height. This workbench should allow you to clamp the material to it to keep your hands free.

Let the tool do the job

Tools should not demand too much effort. If the right tool is chosen and it is sharp and well maintained, the tool will do the job for you. If a hand tool asks too much effort, a powered tool should be used.

Tools must **not be used beyond their design capacity**. If a mode of operation exceeds the force allowed, it will quickly lead to damage or even to an accident. Extending a wrench with a pipe will put too much strain on the material and it will break.

Fig. 7.4.d Self-sawing-saw

Order, order, order

When working in a space that is not adapted as a workshop, keeping order is of the greatest importance. Other people will be working there too so you need to keep your area **clean and free of obstacles**. Cables should be fixed, left over material and dirt should be removed.

You need to keep the working area of your tools free from any obstructions. Rags, parts, materials and tools should be stored or removed.

Do not let your tools lie around to **avoid tripping**. And don't leave them behind, especially not on places where they can fall later, like on fly bars, trusses or bridges. A tool case can help here.

Be sure you **clean the area**, with special attention to all kinds of filings left behind from the process on the material. Metal or wooden particles can cause serious harm to the hands and feet, especially when actors or dancers work barefoot.

Use PPE's

Just as in every other situation, you need to wear your personal protection equipment when using tools. This can be ear protection, eye protection, protective shoes or breathing protection. To know exactly which PPE's are appropriate, you can look in the tools' operating manuals for advice.

With power-operated tools, there is always a risk that clothes, hair or jewellery are caught by the machine. Therefore, it is important to wear tightly fitting clothing, no gloves or jewellery. Long hair should be bound or worn in a hairnet.

Secure on height

Tools used on height should be kept on a **lanyard**. The risk of dropping a tool while using it is too high.

If you use a power cable or air pressure hose, you need to avoid that an accidental pull or the weight of the cable would bring you in **unbalance** when working on height. Secure the cable or the hose and leave enough slack for you to work.

Pic. 7.4.3 safety lanyard

Working with powered hand tools

All risks arising from working with hand tools also apply to powered hand tools. But on top of this, there are some extra risks:

Risks

- Cutting injuries from machines still turning after being switched of.
- Uncontrolled machine movements caused by cutting or hooking in the material.
- Falling caused by unexpected forces (especially on ladders).
- Cutting your own power supply.
- Getting tangled in your cables.
- Long-term effects of hand-arm vibration.
- Effect of noise.

- Effect of dust.
- Sparks can ignite explosive mixtures.

Precautions

- Perform visual check before use.
- Before drilling, nailing, cutting, or sawing into walls, ceilings, and floors, check for electrical wires, water pipes or equipment.
- Adapt your tools and PPE's to the environment (wet conditions, explosive environment, unstable locations).
- Use proper PPEs adapted to the job.

- Use tools that are polarized or double insulated only.
- Switch on and off via the device switch only.
- Do not remove or block safety precautions like dead man's buttons etc.
- Any shock or tingle, no matter how small, means that the tool or equipment needs to be checked.
- Put cable over shoulder to avoid contact with turning parts.
- Unattended power tools must be switched off.
- Do not use electrical equipment in explosive environments.

- Tools with moving parts must have proper guards, do not remove them.
- Check the guards and other protective equipment every time you change settings.

- Operate hand machines with both hands, use the provided handles and choose a stable posture.
- Proper vacuum cleaners must be used to reduce dust.

- Do not work with dull tools since this creates an unacceptably high risk of kickback and poor working.
- Before changing tools, adjusting and cleaning, switch off the machine and pull the main plug.
- Empty dust collectors and filters regularly.

- Don't lay the machine down when it is still turning, wait for the tool to stop.
- When leaving the workplace, switch off machines.
- Do not distract people who are working with machines.

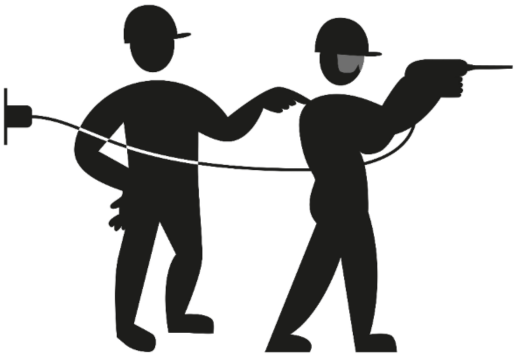


Fig. 7.4.e Short-cable

Power supply

Powered hand tools need a power supply to function. This can be electricity, batteries or air pressure. Each of these energy sources needs specific precautions to guarantee a safe and sustainable working environment.

Electrical supply

To connect your powered hand tool to a power supply, you need cables that are **mechanically strong**, adapted to the required power and to the **weather conditions**. Be sure you have enough cable to move around freely and to choose the best position to work.

Place your cables in such a way to keep you from tripping or your cables from getting caught by the machine's rotating parts. Keep enough slack in your cable or secure it close to the machine. This way, if someone trips, the person working with the machine won't be pulled along. Put the cable **over your shoulder** to stop it from getting in the machine.

Do not overload splitter boxes. Distribution boxes should protect against overload. Use a **ground fault circuit interrupter** if your tools are operated outdoors or in damp or wet locations. This can be a separate one, or be part of the distribution box. All these safety devices have to be tested regularly.

Batteries

Some powered tools use batteries instead of a permanent power supply. The batteries need to be loaded according to the manufacturer's guidelines and kept in condition when not in use for a longer time.

A battery generates heat during loading, this can cause fire or the battery can explode. Be sure the batteries are loaded in a safe and **well-ventilated environment**.

Damaged batteries can leak and spill acids.

Air pressure

Air pressure hoses should be kept free, just like power cables. You need to pay attention to **bad connectors**. Unexpected disconnection of a hose can make it fly and push around. This can lead to serious injuries. Leaks or cuts in the hose can spread dust.

When using air pressure for cleaning, a special **oil filter** must be added to remove oil from the air, to prevent it from polluting the cleaned surfaces.

The compressor has to be tuned to the **pressure** adapted to the job. The air reservoir has to be deflated on a daily basis to release the gathered fluid.

Terms and definitions

- tool
- hand tool
- powered hand tool
- multi-tool
- double-insulated tool
- lanyard
- dead man's button
- guard
- air pressure
- power supply
- ergonomic design
- wear and tear
- compressor

8.1 Hand tools

At the end of this block, you:

- Recognise the different hand tools used on stage.
- Know what the possible risks are.
- Know what protective measures to take.

Hand tools are the oldest means of man's work. Despite the development of mechanized technology, they are still an indispensable help today. Despite construction, manufacturing and material improvements, you should always be aware of the possible risk of injury when dealing with hand tools.

The most common tools on stage are knives, screwdrivers, wrenches, hammers, saws (wood/metal), and clamping tools. We give a short overview of the respective risks and possible precautions:

Pic. 8.1.1 knife

Knife

We use different types of knives on stage to open boxes, cut ropes, strip cables, etc. In order to cut, we need to apply force on the knife. When the knife breaks or slips, this force can cause the knife to cut your skin or clothes.

In general, it is safer to **cut away from yourself**, because if the knife slips, the force moves it away from your body. It may seem strange, but **a sharp knife is safer than a dull one**. The sharp one needs less force to cut, so the chance that it slips or penetrates your body is less. Lots of accidents happen when people grab the blade of a knife when searching in their pockets or toolbox. The best way to avoid this is to **always retract or protect the blade**.

Screwdriver

Pic. 8.1.2 different tips

We use all kinds of screwdrivers on stage. The variation of tip shapes, sizes, and other properties for specific uses, like insulation or magnetic fields is endless. A screwdriver is **designed to drive screws in or out**. This seems obvious, but people seem to also use them for marking, scratching, punching holes, or as crowbars. This (mis)use causes obvious risks. Not only is there a risk that the screwdriver slips, it will also deform and cause risks when used later to screw.

Screwdrivers should **match the tip and size** for safe use. A mismatch will cause the screw head and the screwdriver to be damaged. For this reason, a screwdriver with a worn or broken tip should be replaced. A screwdriver that doesn't match, can slip and cut or puncture your skin. It sounds logical, but it is better to use new screws then worn out ones.

Screwdrivers are meant to put force on the screw, a large handle will ensure better **grip**. Make sure that the screwdriver handle is intact, free of splits or cracks, and clean of grease and oil. Don't extend the force arm by using pliers on the handle. If needed, use a screwdriver with a square shank designed to use it with a wrench. Do not use a hammer on a screwdriver, except if it is meant for it. Fragments of metal can crack off and damage your eyes.

When working with wood, drill a properly sized **pilot hole** at the full length of the screw first. This way, you only need enough force to keep the tip in contact with the screw head. The screw will pull itself into the material with minimum pressure and guidance. Self-tapping screws can be used without a pilot hole.

One of the most common accidents with screwdrivers is caused by holding a **small item** in one hand and trying to screw into it. The object is not stable and the screw or the screwdriver can slip and puncture your hand.

Do not use grinders to restore tips, the heat can destroy temper and reduce the hardness of the tip. The tip will deform easily and make the screwdriver useless.

Wrench

We use wrenches or spanners to get grip on bolts and nuts we want to fasten or loosen. There is a variety of types, sizes and properties developed for different purposes. Wrenches are rather simple tools and injuries are often not serious, but the injuries can be severe enough to get you to the hospital and make you lose time from work.

Wrenches should always **fit tightly** to the surface of the bolts and nuts and have a maximum connection surface. Otherwise, you risk damaging the surface or the wrench could slip away. You have to take special care in an international environment where imperial and metric sizes are mixed.

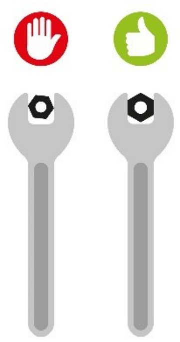


Fig. 8.1.a wrench size

Wrenches should **not be extended**, or hit with a **hammer** when bolts or nuts are stuck. They are not designed for these forces and could bend, break, or fly off and hit you or someone else. Never use pliers instead of a wrench or use a wrench as a hammer.

When possible, it is better to **pull** rather than push the wrench. Pull on a wrench using a slow, **steady pull**; do not use fast, jerky movements. If the bolt would suddenly loosen, it reduces the risk to hurt your hand and knuckles. Gloves help you to protect your hands when doing this.

Be prepared in case the wrench slips. Make sure your footing is solid, your stance is balanced, and your hands are clear.

The most commonly used types of wrenches in event and performing arts are:

An **open-ended spanner** is the most general tool to span bolts and nuts. The advantage is that you can grip a nut, even if it is in the middle of a long bolt. The disadvantage is that it slips off the bolt easily.

Pic. 8.1.3 open ended spanner

A **ring spanner** grips all faces of a bolt and the chance of slipping off is smaller. A disadvantage is that you need to slide the ring over the bolt, which can be difficult if the bolt is connected at both sides.

Pic. 8.1.4 ring spanner

A **combination spanner** combines the advantages of the open ended and the ring spanner.

Pic. 8.1.5 combination spanner

A **combination spanner with ratchet** is used more and more. The advantage is that the spanner can stay around the bolt when being used.

Turning the direction can simply be done by flipping the spanner. Sometimes

Pic. 8.1.6 combination spanner with ratchet

they have a pawl to change the direction.

A **hex key or L wrench** is used for bolts with a hexagonal socket. L wrenches are also available for other types of socket bolts, like torx.

Pic. 8.1.7 Hex key

Adjustable spanners adapt to the size of a bolt or nut. In general, we only use them when we don't have a spanner of the right size available. Adjustable wrenches need to be checked for wear on the knurl, jaw, and pin before use.

Pic. 8.1.8 adjustable spanner

When turning an adjustable wrench, the direction of the turn should be against (towards) the permanent jaw. Make sure adjustable wrenches do not "slide" open during use. Never pull on an adjustable wrench that is loosely adjusted.

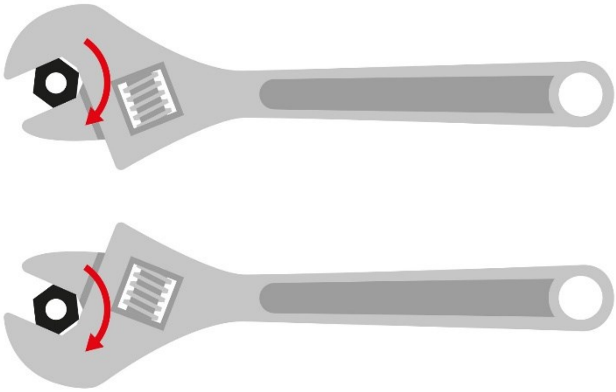


Fig. 8.1.b wrench direction

A wide range of adjustable wrenches are available on the market. A lot of them belong to the hobby market and are not suitable for professional work. The disadvantage of these spanners is that they cannot get a proper grip on the bolt. In most cases you will damage the bolt head and not untighten the bolt.

A **ratchet wrench** is a socket wrench with a ratchet mechanism, allowing the bolt or nut to be turned with repeated movements and without removing the socket from the nut or bolt. In most cases, the sockets are interchangeable and extra accessories are available to extend the socket. The turning direction can be changed by changing the pawl or inserting the socket on the other side of the wrench.

Pic. 8.1.9 wrench ratchet

When **extensions** are used, you need to support the head of the ratchet wrench. Avoid the use of socket wrenches **at heights**, as the sockets and other accessories can fall.

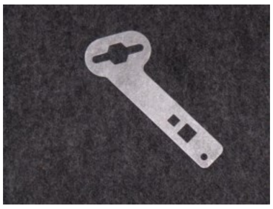
Pic. 8.1.10 extensions

Some wrenches are specifically made for the event and theatre sector. They fit specific needs and have a connection for a lanyard to work safe on heights.

A **shackle buster** is used to unscrew the bolts of shackles without damaging the eyes of the bolt.

Pic. 8.1.11 shackle buster

A wingnut wrench is used to tighten or loosen wingnuts on spotlight clamps.



Pic. 8.1.12 wingnut wrench

A **scaffolding wrench** is a ratchet wrench that has the most commonly used sizes of sockets (19/23) built in. In this way, there are no lose parts that can fall. The pointed other end can be used to loosen the pens of a scaffold system.

Pic. 8.1.13 scaffolding wrench

Hammer

Hammers come in different types, sizes, materials and purposes. Choose a hammer with the **right weight and size for the job**. The head size should be slightly larger than the surface you strike.

Check the handle and the head for damage or bending. Ensure the head is properly attached to the handle. The handle should provide a good **grip**. Ideally the hammer has a **cushioned handle** to protect you from vibration, impact, and squeezing pressure. Wooden handles have a **keg** diagonal in the handle to keep it in place. Replace loose, cracked or splintered handles or take the hammer out of service.

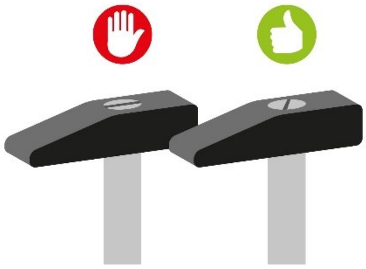


Fig. 8.1.c keg

To use a hammer in an optimal way, you take the **handle at the end** to have maximum profit of the lever. **Use your wrist** to strike with the hammer and not your whole arm and elbow. This improves accuracy. Let the weight of the hammer do the work!

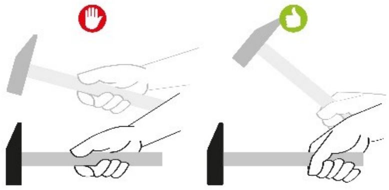


Fig. 8.1.d use arm

The hammer should **hit the surface** square, in order to have an equal impact. This also avoids damage on the surface.

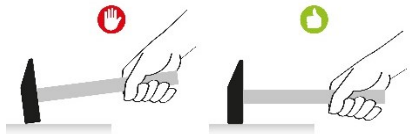


Fig. 8.1.e hit square

When driving nails, **hold the nail as close to the head as possible**, to avoid injuries when the nail slips. Place your work on a hard surface to maximise the impact. Soft surfaces will absorb your energy.

Fig. 8.1.f hold nail

Always **look behind and above you** before swinging the hammer. Keep enough **clearance** from fellow workers and objects. Maintain a secure footing and keep **good balance** while using a hammer.

Do not use a hammer for **other purposes** than intended. Do not strike another hammer, other hard metal objects, stones or concrete. Do not strike with the side or cheek of the hammer. Avoid hitting hard surfaces with the handle.

The most commonly used hammers in event and theatre environments are:

The **claw hammer**, which is used for general carpentry. It has a round head for striking on one side and a claw to pull nails out on the other side.

Pic. 8.1.14 claw hammer

To remove or tighten truss pens, we need a **mallet**. This is a hammer with a softer head surface. The surface can be nylon or copper. These materials do not damage the aluminium pens. This type of hammer can also be used to bring elements together. If there is no mallet available, you can also put a piece of board or other soft material on the surface to avoid damage.

Pic. 8.1.15 copper mallet

Pic. 8.1.16 Nylon mallet

A **scaffolding hammer** is used to erect and dismantle scaffolding. The hammerhead is used to tighten the pens and the sharper pen side is used to remove the pens.

Pic. 8.1.17 scaffolding hammer

Saw (wood/metal)

A saw is a tool to cut wood, metal, or plastics. The saw has a blade with teeth along the edge. Depending on the material and the accuracy of the cut required, the saw will need more or **less teeth per inch**. In general we can say that the finer the cut or the harder the material the more teeth per inch we will use.

A saw should be **sharp** and the teeth need to be **protected** when not in use.

Before you start **sawing wood**, check the material for nails etc. that can damage the saw. Secure the material in a supporting bench or vice. Start the cut by placing your hand beside the cut mark with your thumb upright and pressing against blade. Start to cut carefully and slowly to prevent the blade from jumping. Pull upward until blade bites. Start with partial cut, then set saw at proper angle. Apply pressure on down stroke only.

To saw metal, a saw blade is **tensioned** in a bow, keeping it straight. The teeth are pointing away from you. Keep saw blades clean and lightly oiled. **Clamp** thin, flat pieces to secure them. **Cut using steady strokes, directed away from you**. Cut harder materials more slowly than soft materials. Do not apply too much pressure on the blade as the blade may break.

Clamping tools

Clamping tools are used to temporarily **hold materials worked on securely in place**. In that sense, they don't pose much risks when using, but make work more safe. They stabilise materials to work with other tools.

In event and performing arts situations, they are also used to **hold sets or other elements together** temporarily. In these situations, they can pose a risk when loosening and falling.

Check the clamping tools for bending, damaged spindles, dirt or corrosion. Be sure that the whole clamping surface is in **contact** with the material.

What you need to remember

The most common tools on stage are knifes, screwdrivers, wrenches, hammers, saws (wood/metal), and clamping tools.

Terms and definitions

- hand tool
- pilot hole
- screwdriver tip
- wrench / spanner
- ratchet wrench
- spanner with ratchet
- hex key or L wrench
- keg
- mallet
- shackle buster
- wingnut wrench
- scaffolding wrench
- claw hammer

Rehearsal questions

08.01.01 True/False

- Sharp knives are safer.

08.01.02 True/False

- A screwdriver can also be used for marking, scratching and punching holes.

08.01.03 True/False

- A hammer is a good tool to use on a wrench when a bolt gets stuck.

08.01.04 True/False

- Ideally, the size of the head of a hammer is slightly larger than the surface you can strike.

08.01.05 True/False

- It is good to keep a saw slightly oiled.

08.01.06 True/False

- Clamping tools actually never cause any risk.

8.2 Powered Hand tools

At the end of this block, you:

- Recognize the different powered hand tools used on stage.
- Know what the possible risks are.
- Know what protective measures to take.

Powered hand tools are small machines that are hand held and can move with you in the work place. Here, we limit ourselves to tools that are often used on stage. The most common tools are a cordless screwdriver, a soldering iron, a drill, a stapler or nail gun, a hot glue gun, an oscillation saw or a circular saw. Grinders, sanders and other not relevant or too specialised tools are not discussed here.

Cordless screwdriver

A cordless screwdriver is a small, battery powered drill that has speed, direction and torque control. The torque control defines the force used to drive the screw in or out and limits the risk of uncontrolled movement of the machine when the screw gets blocked.

Fig. 8.2.a Cordless James

When a screw is blocked, this can cause a slam hurting your hand, bringing you out of balance or making you drop the machine. This is why you have to be very careful when working with machines at height. Be sure no one is below when using the tool on high locations.

Just as with a manual screwdriver, there is a risk to puncture your hand when the bit of the machine slides off the screw. It is important to choose a bit that fits tightly to the screw. Do not touch the bit or the work piece immediately after operation; they may be extremely hot and could burn your skin. Ensure that cutting tools, drill bits, etc. are kept sharp, clean and well maintained. Ensure that the tool is switched off or locked before changing accessories, making adjustments, or storing the tool.

Always be sure you have a **firm footing** when working with a machine. Hold the tool firmly and keep your hands **away from rotating parts**. Hold the tool by **insulated gripping** surfaces, when the fastener may contact hidden wiring. Fasteners contacting an electrical conductor may make exposed metal parts of the power tool "live" and could give the operator an electric shock. Keep handles dry, clean and free from oil and grease.

Only use batteries that are specified for your tool and only recharge them with an adapted charger. Using the wrong type of battery or un-adapted charger may create a risk of fire or even explosion.

Don't store batteries together with **metal objects** that can come in contact with the battery terminals. **Shorting the battery** terminals can cause a large current flow, overheating, sparks, possible burns, and even a permanent failure of the battery. Do not expose battery cartridges to water or rain.

When a battery is **damaged**, a liquid, the electrolyte, can spill. The electrolyte can cause irritation or burns. If the liquid gets into your eyes, immediately rinse with water and seek medical help. Never use a damaged battery. Be careful not to drop or strike battery, do not disassemble it or incinerate it. Batteries have to be treated as hazardous waste.

Cordless screwdrivers can also be used to **drill**, but mostly only in rather soft materials like wood and plastics.

Soldering irons / soldering stations

We use soldering irons or stations to repair cables or replace electronic components. Soldering is a process to join two metals (mostly copper) with filler metal (solder).

The most obvious risks are caused by the **melting temperature** (400 °C) the soldering iron needs to reach to melt the solder. The solder iron and the melted solder can cause burns, but can also cause fire. You have to work on a stable, fireproof surface, keep the iron in a stand and unplug it when not in use.

A second risk is posed by the solder itself. Depending on the composition, it can contain **lead and rosin**. The fumes produced when heating the solder are hazardous and need to be extracted. In a repair workshop, this is done by a permanent extraction system. Waste solder and solder sponges are considered hazardous waste. When you are soldering on a day-to-day basis, health surveillance is required.

Drills

A drill is a powered tool that drives a drill bit into a material to bore holes. The drill bit is mounted in the chuck of the tool. The drill bit is the cutting tool that removes material to create a hole. The type of drill bit needs to be adapted to the material we want to drill a hole in. Drill bits come in different sizes, harnesses and shapes. Most important types are:

Twist drill bits are universal bits, that can be used for metal, wood or plastics. This is the most common bit.

Pic. 8.2.1 Universal twist drill bit

For wood, **spade bits** and **lip and spur bits** are used. This type of drill bit is only usable for wood. The sharp point in the centre ensures that the bit doesn't drift on the material.

Pic. 8.2.2 Lip and spur bit

Pic. 8.2.3 Spade bit

For masonry and concrete, we use **masonry drill bits**. They are mostly used with a hammer drill. Masonry bits have a hardened insert in the tip that can resist the hammering of the bit into the material. These types of bits have a specific SDS connection that clicks in a bit shank that allows movement in the direction of the hammer, but avoids slipping.

Pic. 8.2.4 Masonry drill bit

Pic. 8.2.5 SDS bit connection

SDS stands for : "Stecken – Drehen – Sichern" (Insert – Twist – Secure)

Drill bits are the part that does the actual work, so they must be chosen carefully and kept **clean and sharp**. Lock the bit firmly in the chuck, using a chuck key, and remove the key immediately. When the tool starts, the key could fly away and hit someone.

Before you start, check if there are no electrical wires, water pipes or other elements that can be damaged **under the surface**. Check the setting of the drill (hammer / normal) and adapt the speed to the material and the size of the hole.

Secure your work piece. Don't hold the work piece in your hand or on you knee. Make a pilot hole to avoid drifting of the drill bit. This makes your work safer and more accurate.

Use both hands when drilling. If both hands are holding the drill then it is impossible for the user to accidentally place your hand in the way of the drill. Stand in a comfortable position, **in balance with proper footing**. Use your own weight to apply force on the drill, but do not support yourself with the drill. **Let the drill do the work!** If you have to apply a lot of force, this probably indicates your drill bit is not sharp enough or your drill is not powerful enough. Loose clothing, jewellery or long hair can get caught in the drill chuck.

Be prepared for the drill bit to block. A sudden **torque** can twist your arm and throw you off balance. When you have to drill deep holes, redraw from time to time to remove cuttings from the hole.

Stapler/nail gun

Nail and staple guns are tools to drive nails and staples in wood. They are used in set building, where lots of fasteners have to be driven in. In fact, they have replaced hammers for many carpenter activities. In event and performing arts workshops, they are mostly powered by air pressure or electricity.

Fig. 8.2.b nail gun duel

Nail guns are very powerful tools, but they can also be **very dangerous** if not properly used. Puncture wounds in hands or arms and eye damage are the most common types of injuries, but deadly accidents happen. Therefore proper training is needed before using this tool.

All nail guns need to have a **safety device** that only allows to fire if the nose is pushed to a surface. Depending on the type, the safety device has to be released every time to fire a second time (sequential trigger) or you can fire continuously as long as the device makes contact (contact trigger). Sequential triggers are much safer.

Before use, the tool (and the air supply) must be checked. The tool must be clean and all **safety mechanisms** must be functioning. Under no circumstances, the safety mechanisms should be deactivated! The air supply must be adjusted to be sure the air pressure is not above the manufacturer's rating.

Only use the proper type of nails in the gun. After use or when loading, cleaning, clearing a blockage or maintenance, the air supply should be **disconnected** and the remaining air in the tool should be **released**.

Always handle a tool as if it is loaded with fasteners (nails, staples, etc.). Do not carry a tool with the trigger depressed, or carry the tool by its hose. **Never point at another person or yourself**, keep your hands away from the nails' path. Only press the trigger when the nose is touching the surface.

Use proper **personal protection** (eye protection, hearing protection, safety shoes,…). Stand in a comfortable position, in balance with proper footing. Hold the machine firmly in your hand and do not overreach.

Hot glue gun

A hot glue gun is a device to **melt and apply thermoplastic glue**. The glue is inserted in the form of sticks. These sticks are melted by a heating element and pushed out the gun through a nozzle.

The most obvious risk of a hot glue gun is **burns**. Never touch the heated nozzle or the hot glue. Do not use rubber or plastic gloves as they could melt too. If you have glue on your fingers, wipe it off immediately. The sooner you remove it, the less burn and the easier to get it off.

All hot glue guns **leak** glue. Put a fireproof surface under your work piece and under the stand to prevent damage to the underlying surface.

Glue sticks come in different melting temperatures. Check if the **melting temperature** of your gun fits the used glue. Overheated glue can provoke fumes that are toxic.

Use a **safety stand** to hold the hot glue gun when you are not using it to glue items. Never lay a hot glue gun on its side. Keep the hot glue gun away from flammable materials. Never leave a connected hot glue gun **unattended**.

Jigsaw, sabre saw (Oscillation saw)

Oscillation saws are used to cut external or internal contours in wood or thin metal material. They are not meant for long straight cuts. In that case, it is better to use a circular saw. The saw blade of a oscillation saw can **break or get stuck**, creating a kick back. **Dust and particles** can get in your eyes. And there is a risk to cut your hand, a power cable or underlying material, because you can't see under the surface of what you are cutting.

It is important to **choose the right saw blade**, fit for the material and thickness, and **adapt the speed** of the saw to it. Check if all safety provisions are in place and if the saw is fixed properly. Disconnect power supply before changing or adjusting blades and never leave plugged-in tools unattended.

Secure the material, otherwise it starts vibrating, and this can cause the saw blade to break and less accurate work. **Check what is under the surface** and make sure that the saw can't contact the power cable, clamps, the vice, workbench, or other support.

Wear safety glasses and hearing protection. Use both hands to manipulate the saw, keep a stable footing and don't overreach. Never reach under, around, or behind the material being cut.

Start from the side of the material or make a lead hole first, the hole should be at least 3mm larger than the saw. Don't start cutting with the blade in contact with the work piece. Ensure the saw can **move freely when starting**. Let the saw reach full power before it touches the work. Never try to insert a blade into, or withdraw a blade from, a cut or a lead hole while the motor is running.

Hold the base or shoe of the saw in firm **contact with the work piece**. This keeps the blade cutting straight up and down and prevents it from twisting or breaking. Do not try to cut curves so tight that the blade will twist and break. Never put the saw down until the blade and motor have stopped.

Let the saw and the blade do most of the work. **Don't force the saw**. The machine should turn with ease. If you have to push the saw, the blade is too dull or the material is too heavy for the saw.

Hand-held circular saw

A circular saw is a tool that drives a toothed circular saw blade to cut wood. It is often used for set building in smaller or temporary workshops. If not used correctly, it can cause serious injuries. The main risk factor is the kickback of the saw, when the blade gets stuck in the material. Dust and particles can get in your eyes. And there is a risk to cut yourself, a power cable, or underlying material, because you can't see under the surface of what you are cutting.

Of course you need to wear the proper **personal protection** when operating the saw. Safety glasses, hearing protection, and appropriate footwear are essential. Loose clothing, jewellery or long hair can get caught in the saw.

Take care to choose **the right blade for the job**. Blades are available in a variety of styles and tooth sizes and for different types of cuts. Be sure the blade is installed in the proper rotational direction. Ensure that the blade that you have selected is sharp enough to do the job. Sharp blades work better and are safer. Sharp blades with properly set teeth will reduce the blocking, kickback and overheating.

Set the **depth of the blade**, and lock it. The tooth should extend the material only 5mm below the piece of material that you are cutting. This makes the risk for kickback smaller. Always unplug the tool before changing blades, cleaning the saw, or making adjustments. Never use a saw that vibrates or appears unsafe in any way.

Check the retracting lower **blade guard** to make certain it works freely. Never wedge, or jam the guard to prevent it from working. Check that the blade guard has returned to its starting position before laying down the saw. Never hold the guard in the open position.

Fig. 8.2.c saw blade Ninja

Check that your material is free of nails and other foreign objects. These can damage the blade or make it kickback. **Secure** the piece and check if nothing is in the way of the blade under the surface. Never hold a work piece in your hand, on your knee or on your foot. Check if the power cords are safe from the blade.

Stand to one side of the cutting line, in balance with proper footing and position yourself so that you are in control of the saw and the material. Do not overextend your body when cutting. Never reach under the material being cut. If cutting right-handed, keep the cord on that side of your body.

Let the saw reach full power before starting to cut. Operate the saw with **two hands** and use just enough force to let the blade cut. Do not force the saw during cutting. If the cut gets off line, don't force the saw back onto line. Do not twist the saw to change, cut or check alignment. Withdraw the blade and start over on the same line or begin on a new line. **Never pull the saw backward** when cutting. Always be aware of risk for kickback when using a circular saw. Release the switch immediately if the saw blocks.

Before putting the saw down, make sure the **guard** is in place. Never carry the saw by the cord or with your finger on the trigger.

Other powered hand tools

We cannot discuss all the tools you will encounter in the future here. New tools are invented and existing tools are improved. The principles and methods that are described above will help you to work safe, in combination with the **information provided by the manufacturer** and the **training** you get from your employer.

What you need to remember

The most common powered tools used on stage are a cordless screwdriver, a soldering iron, a drill, a stapler or nail gun, a hot glue gun, an oscillation saw, or a circular saw.

Terms and definitions

- powered hand tools
- cordless screwdriver
- insulated gripping
- shorting (the battery)
- soldering iron
- lead
- rosin
- twist drill bit
- spade bit
- lip and spur bits
- masonry drill bit
- SDS bit connection
- torque
- nail gun
- staple gun
- hot glue gun
- jigsaw
- sabre saw
- oscillation saw
- circular saw
- saw blade

Rehearsal questions

08.02.01 True/False

- If a torque control of a cordless screwdriver is used, it can never block.

08.02.02 True/False

- Soldering is a process to join mostly copper with filler solder.

08.02.03 True/False

- The type of drill bit seldom needs to be adapted to the material we want to drill a hole in.

08.02.04 True/False

- SDS drill bits can be used for every kind of material.

9 Work safely with chemicals

To Work safely with chemicals, you must:

Take the necessary precautions for storing, using and disposing of chemical products.

This means you master following skills:

- Identifies products based on manufacturers' information, safety information sheets, etc.
- Takes precautions
- Chooses the right tools to handle the materials
- Ensures work environment is clean, clear and stable
- Prevents unnecessary exposure to chemicals
- Ensures ventilation
- Works according to the safety instructions
- Stores chemicals according to regulations
- Disposes chemicals according to regulations
- Acts according to the agreed procedure in case of an accident

You master following knowledge:

- Risks and Labels of hazardous substances
- Safety data sheets
- Storage of hazardous substances
- (Danger signs)
- (Body protection)
- (Eye and face protection)
- (Breathing protection)

You have following attitudes:

- Safety awareness
- Awareness of long term impact on personal health
- Awareness of risk for other persons' exposition and allergic reaction during work with chemicals
- Respect for safety warnings and instructions

In theatre, events, workshops, storage areas, dressing rooms,… we are exposed to a lot of different chemical products during our work. Whether this exposure to different substances leads to health damage, depends on the nature of the substance, the type of exposure (inhalation, ingestion, contact with the skin) and the degree of the exposure. Long-time exposure, even to small amounts, increases the risks. Effects may occur immediately after exposure or may have a delay (after hours, weeks, years). The effects range from small inconveniences and allergic reactions up to severe poisoning and instant death.

Recognising the hazardous products and **understanding** the risks is a first step to keep you and your colleagues safe. Proper training and information on how to handle, store and dispose of chemicals is essential to be able to work with them safely. Preparing for emergency, being alert for your and other people's reactions and knowing what to do in case of an accident are the final elements to ensure a safe working environment.

Products used in theatre

The range of products we use in a theatre and event environment is wide and unlimited. Below we describe the most common (possibly) dangerous substances to which workers in the performing arts and events can be exposed. But you have to stay alert for each new product entering the workplace and every new type of application. Every new product, combination of products or process has to be checked for possible hazards before it is used.

Fig. 8.2.a Smoking-bottle

Products used for sets

When working on sets, especially in the finishing phase, we use a lot of chemical compounds. These products have a range of hazardous properties, so it is extremely important to read the safety data sheets. We sum up some of the most used products with possible hazards:

Paints, varnishes, thinners, glues

- Can be toxic, flammable and explosive.
- Can be irritating for the skin and eyes.
- Fumes can be irritating or toxic when inhaled.
- Unexpected chemical reactions can occur when mixing products.
- Can cause dizziness or even hallucination.
- Can cause environmental damage (even water based products).

Pic. 8.2.1 scenic painter at work

Epoxy and isocyanates used to make thermosets

- Create heat as a reaction when mixing and applying.
- Can cause allergenic reactions.
- Fumes can be irritating or toxic when inhaled.
- Can stick to the skin.

Linseed oil and two component products

- Can combust spontaneously.

Polyesters, resins, two component glues

- Can generate toxic fumes.
- Can produce heat when mixed.

Cleaning and degreasing agents

- Can be toxic and corrosive.
- Unexpected chemical reactions can occur when mixing products.

Products used for lighting

Light bulbs contain different products that can be hazardous. They do not create any hazard when in use, but can cause intoxication when broken. You need to take extra care of specific bulbs that radiate UV or other dangerous frequencies of light when in use.

Gas discharge lamps

- Contain mercury or similar products.
- Lamp under pressure, can explode

Tube lamps

- Contain fluorescent powder that is toxic.
- If in a wound, the powder keeps blood from clotting.

Products used for special effects

Products for special effects are the field of specialists. But everyone will come into contact with them in de sideline of their work. Below you will find some of the most commonly used products:

CO2

Dry ice or frozen carbon dioxide (CO2) is applied to create fog effects. CO2 is not toxic, but the use can have dangerous side effects.

Pic. 8.2.2 CO2 effect

- The temperature of CO2 in a frozen state is about -80 ° C. This can cause severe frostbite or cryogenic burns.
- In a gaseous state, it is heavier than air and sinks to the ground where it reduces oxygen levels and can cause suffocation. Pay attention to leaks to lower floors.
- When heated in a closed container, the gas expands and causes a risk for explosion.
- The application in combination with water can cause slippery floors

Liquid nitrogen

Liquid nitrogen is used for large-scale fog effects. It works in a similar way as CO2, except for the fact that it is still liquid at a temperature of -198 ° C.

- The liquid can cause frostbite or cryogenic burns
- The gas reduces oxygen levels and can cause suffocation.
- The application in combination with water can cause slippery floors

Liquid nitrogen is also used in combination with liquid oxygen. In this mix, there is no risk for reduced oxygen levels.

Salmiac salt

Salmiac salt also called Mystery Powder decomposes into a haze used for effects by heating it. Heating the salt forms ammonia NH3 and hydrochloric acid HCl as intermediates, which in turn precipitate as NH4Cl (salmiak) during cooling. These are harmful substances that can cause a serious threat for the eyes and respiratory system. This is why the use is no longer allowed in most countries.

Gas and pyrotechnical material

For special effects gas (in cans) and pyrotechnical material is used. These high-risk products should be stored, moved and used only by specialised persons. Risks are:

- Fire hazard
- Explosion danger
- Toxic particles or fumes from combustion

Products used for hair, wigs, and makeup

Products used for hair, wigs, and makeup can cause health issues. Breathing in fumes of products, but also exposure to skin and eyes can cause hypersensitivity, eczema, allergic reactions, irritation of eyes and skin. Not only the people working with the products, but also the ones the products are applied on are at risk. Long and regular exposure to the products will increase this risk. Products that can cause a hazard are, for example:

- Nail varnish and remover, wig glue
- Make up
- Moulding, latex forming, …
- Hair dyes

Products used on fabrics, costumes and soft goods

When working with fabrics, costumes and soft goods, a lot of chemicals are used to dye (colour) them, remove stains, dry clean them or make them fireproof. These products can irritate or even burn skin or eyes and be harmful when inhaled. Other products like bleach are oxidisers and should be stored in a specific way. Products that can cause a hazard are, for example:

- Dyes
- Stain removers
- Dry cleaning products
- Fireproofing liquids
- Bleach

Fumes from workshop processes

Soldering, welding and spray painting in a workshop creates fumes that are hazardous and can be toxic when inhaled. Some products released in the fumes are lead for soldering and thinners for spray painting. Forced ventilation has to be present. This can take the form of a hood or even a separate cabin to work in.

Products in high-pressure packages

Spray cans or cans with liquids for fire effects keep their content under pressure. This causes a risk for explosion when they heat up or come into contact with fire. The products inside are flammable and add to the fire risk.

Substituting hazardous chemicals

The best way to minimise chemical hazards is to replace the products with harmless products. Even if this is not your responsibility, proposals based on your experience on the floor will be welcomed.

Information, training and medical fitness

Employees must be **informed** about the risks of the substances with which they work, and how those risks can be limited as much as possible. The information should be available on site for reference.

The employees have to be **properly trained** in the use of the products and for emergency situations. For certain substances, specific procedures have to be followed and a training certificate can be required.

Fig. 8.2.b Safe

You need to make a **risk analysis** for the application of the hazardous products. This will make risks for allergic reactions and other possible health issues visible. An approved medical examination needs to guarantee that the individual worker is fit to work with the products and the risk is within acceptable limits. For pregnant women, minors, and people with reduced resistance specific provisions need to be made, based on risk assessment.

Depending on the country, the **certification and medical check-ups** have to be repeated on a regular base. (For example, Sweden requires re-certification every five years).

How to recognize hazardous substances?

Hazardous products have to be identifiable. Therefore, the manufacturer has the duty to put a corresponding **pictogram** and a **product label** on each container. This provides you with basic information about the product, the way to use it,… These labels work a lot better if you read them! Before you open a bottle or a package you need to know what you are dealing with!

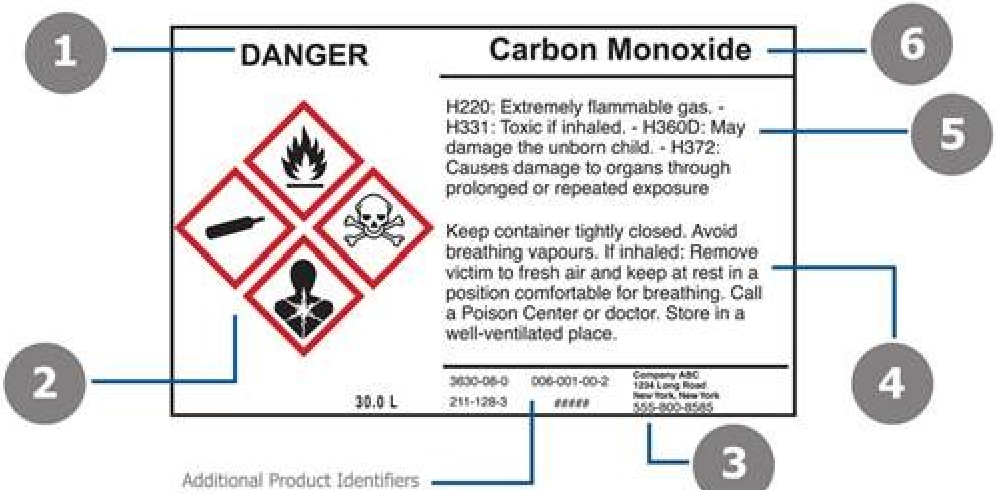
It is not recommendable to put products in other recipients, but if you do so, you need to ensure the recipients are properly labelled.

The manufacturer has the duty to provide a **safety data sheet** for each product. This document provides all the information needed in regular use and in case of emergencies. These sheets should be at hand in the workplace as part of the **hazardous substance register**. This register ensures an overview of what products are present in the work place.

Product labels

The Globally Harmonized System (GHS) is an international system that the United Nations created for the unified classification and labelling of chemicals.

The phrases that give important information about the harmfulness of the substance(s) are also listed on the Material Safety Data Sheets (MSDS) that each supplier MUST deliver.



Pic. 8.2.3 product safety label

1 **Signal Word**: The signal word indicates hazard level. "Danger" is used for the most severe instances, while "Warning" is less severe.

2 **GHS Symbols** (Hazard Pictograms). These pictograms are used to identify hazardous products and are commonly grouped by chemical/physical risk, health risk and environmental risk.

3 **Manufacturer's Information**. This identifies the manufacturer's company name, address and telephone number.

4 **Precautionary Statements/First Aid**. These are phrases that are tied to each hazard statement. They describe precautions for general prevention, response, storage or disposal. These statements are found on the chemical's Safety Data Sheet. Similar to Hazard Statements, Precautionary Statements can be identified by a P-Code (like P100).

5 **Hazard Statements**. These are phrases that describe the nature of hazardous products and the degree of hazard. Hazard statements are on the chemical's Safety Data Sheet (SDS) and identified by an H-Code (like H100).

6 **Product Name** or Identifiers. This identifies the product or chemical name. Additional identifiers can be noted to the right of the Manufacturer's information

Safety data sheets

Safety data sheets provide the users of chemicals with the **necessary information** to help them protect human health and the environment. Safety data sheets are intended both for the workers who handle the chemicals and for those responsible for safety.

The safety data sheet contains more information than the product label on the container. It contains all the information you need to work with a product in a safe and sustainable way and to be prepared for possible incidents. Therefore, the safety data sheets of all the products available on stage should be within reach.

The safety data sheet is divided into **16 sections**, and each section contains information on a specific topic or for a specific user.

The safety data sheets should be at hand in the workplace as they contain all the information you may need in case of an emergency. If you have an **emergency** and seek **medical help**, take the safety data sheets with you. They identify the exact nature of the product, and contain emergency telephone numbers and specific information for medical helpers.

Using chemicals

Products we use are very diverse, so it is difficult to give exact instructions. That is why reading the safety information sheets and a proper training are crucial to use chemicals in a safe way. Some basic rules apply to most situations:

- Proper/relevant/necessary PPEs, fire protection equipment, and cleaning products **should be at hand before you start working.**
- Take precautions **before** you start working.
- Ensure your work environment is **clean, clear and stable**.

- Work according to the safety instructions and training.
- Avoid inhaling fumes or dust.
- Ensure ventilation or work outside.
- Only use chemicals for what they are intended for. (For example, drain cleaner is no paint stripper.)
- Do not mix chemicals and keep them apart.
- Be careful with aerosols, the particles are small and penetrate the skin and get into your longs.
- Don't reuse cleaning rags and don't use them on different products.

- Be aware of your and your colleagues' allergies.
- Prevent unnecessary exposure to chemicals.
- Avoid contact to skin or eyes.
- Choose the proper tools and PPEs to handle the materials (resistant to the product).

- If you have been in contact with chemicals, wash skin and clothes.
- Avoid contact between food and chemicals.
- Do not eat, drink or apply make-up when using chemicals.

Fig. 8.2.c Lunch

- Don't spill chemicals, don't flush them down the drain.
- Collect used chemicals and materials in special disposal bin.
- Dispose of cleaning rags like chemical waste.

- If you don’t understand the instructions, ask for help.
- Make sure you know what to do in case of an emergency.

Moving and Storing chemicals

To move and store chemicals in a safe way, you need to read the safety data sheet with the manufacturer's recommendations and you need to know the procedures, the regulations and legal requirements. Storage of chemicals is a complex matter that we deal with later. But there are some obvious rules that fit all circumstances.

The containers need to be **closed properly** and have **accurate labelling**. The lids should be placed on the container to stop them from spilling. Before moving or storing, the incompatibility of products must be checked and incompatible products are kept away from each other.

Chemicals should never be left unattended. When not in use, they must be stored and kept under lock.

Disposal of chemicals

Chemicals can harm our environment or cause unwanted effects in sewers. They have to be disposed of according to the instructions of the manufacturer and applicable regulations. In most cases this means they have to be gathered in special chemical waste containers and processed by a specialised company.

Under no circumstance should chemicals be mixed, emptied in a sink, or dumped in nature.

Emergency procedures

Prepare for emergencies and take precautions. Don't wait until it is too late and you need them. In case of an accident, every second counts! You have to be able to blindly act accordingly to the agreed **procedure in case of an accident**. You have to know the procedure adapted to the products used. You have to know how eye showers work, where the emergency showers are, what to do in case of poisoning, etc.

Terms and definitions

- chemical product
- chemical compound
- exposure
- allergic reaction
- hazardous product
- safety data sheet
- toxic
- intoxication
- flammable
- explosive
- irritating
- chemical reaction
- environmental damage
- fume
- spontaneous combustion
- corrosive
- carbon dioxide (CO_2)
- cryogenic burns
- pyrotechnical material
- hypersensitivity
- eczema
- fireproof
- forced ventilation
- medical examination
- product label
- Globally Harmonized System (GHS)
- Signal Word
- GHS Symbol
- Precautionary Statements
- P-Code
- Hazard Statement
- H-Code
- emergency shower

9.1 Risks and Labels of hazardous substances

At the end of this block, you:

- Recognize the safety labels for chemicals.
- Understand the risks and the precautions to be taken.

There are many different types of hazards connected to all the products we use. In order to have a first, general idea about the risks, all **hazardous products** are required to have one or more pictograms on their containers indicating the type of risk they pose. The pictograms are in the shape of a **red diamond with a white background**, and replace the older orange square symbols. These pictograms are part of the Globally Harmonized System of classification and labelling of chemicals (GHS).

The pictogram is accompanied by a **hazard statement**. A hazard statement is a phrase assigned to a hazard class and category that describes the nature of the hazards of a hazardous product, including, where appropriate, the degree of hazard. In the list below, they are marked "can mean".

There are different types of symbols and markings depending on their use. We only describe the product pictograms, but there are similar pictograms for transport. Bottles of compressed gas are colour coded to represent the type of gas they contain.

Physical hazard

The first group of signs warns about physical hazards, that harm or **damage the physical environment as well as the human body**. Physical hazards are caused by substances for which there is valid evidence that they are combustible, compressed, explosive, flammable, oxidizers, pyrophoric, unstable, or water (moisture) reactive.

Explosive

Ico 9.1.1 Explosive

Symbol: Exploding bomb

Can mean:

- Unstable explosive
- Explosive; mass explosion hazard
- Explosive; severe projection hazard
- Explosive; fire, blast or projection hazard
- May mass explode in fire

Examples of where we can find it:

- Fireworks, ammunition

Examples of precautionary statements:

- Obtain special instructions before use.
- Do not handle until all safety precautions have been read and understood.
- Keep away from heat/sparks/open flames/hot surfaces. – No smoking.
- Wear protective gloves/protective clothing/eye protection/face protection.
- Use personal protective equipment as required.
- Explosion risk in case of fire.

Flammable

Symbol: Flame

Ico 9.1.2 Flammable

Can mean:

- Extremely flammable gas
- Flammable gas
- Extremely flammable aerosol
- Flammable aerosol
- Highly flammable liquid and vapour
- Flammable liquid and vapour
- Flammable solid

Examples of where we can find it:

- Lamp oil, petrol, nail polish remover

Examples of precautionary statements:

- Do not spray on an open flame or other ignition source.
- Keep away from heat/sparks/open flames/hot surfaces. – No smoking.
- Keep container tightly closed.
- Keep cool.
- Protect from sunlight.

Oxidizing

Symbol: Flame over circle

Ico 9.1.3 Oxidizing

Can mean:

- May cause or intensify fire; oxidiser.
- May cause fire or explosion; strong oxidiser.

Examples of where we can find it:

- Bleach, oxygen

Examples of precautionary statements:

- Keep away from heat/sparks/open flames/hot surfaces. – No smoking.
- Wear protective gloves/protective clothing/eye protection/face protection.
- Rinse contaminated clothing and skin immediately with plenty of water before removing clothes.

Gas under pressure

Symbol: Gas cylinder

Ico 9.1.4 Gas under pressure

Can mean:

- Contains gas under pressure; may explode if heated.
- Contains refrigerated gas; may cause cryogenic burns or injury.

Examples of where we can find it:

- Gas containers

Examples of precautionary statements:

- Protect from sunlight.
- Wear cold insulating gloves/face shield/eye protection.
- Get immediate medical advice/attention.

Corrosive

Ico 9.1.5 Corrosive

Symbol: Corrosion

Can mean:

- May be corrosive to metals.
- Causes severe skin burns and eye damage.

Examples of where we can find it:

- Drain cleaners, acetic acid, hydrochloric acid, ammoniac

Examples of precautionary statements:

- Do not breathe dust/fume/gas/mist/vapours/spray.
- Wash thoroughly after handling.
- Wear protective gloves/protective clothing/eye protection/face protection.
- Store locked up.
- Keep in original container only.

Health hazard

The second group of signs warn about health hazards, **harming the human body**. Health hazards result from exposure to environmental pollutants and hazardous products.

You can be exposed (and overexposed) to hazardous products in various ways.

- **Absorption**: the solvent penetrates your skin. This could be through direct contact with your skin while you clean tools.
- **Inhalation**: you can inhale vapours when you're applying sealants, glue, and paint, or cleaning your tools.
- **Ingestion**: this means swallowing. You can ingest solvents from your hands while you eat, drink, or smoke.
- **Injection**: this can happen when your skin is damaged (wound) or punctured, for example by a high-pressure spray gun.

Different hazardous products can affect your health in different ways. You can pass out and even die from exposure to very high concentrations of vapour. Short-term health effects from exposure include:

- Irritation of eyes, lungs, and skin
- Headache
- Nausea
- Dizziness

Solvent exposure has three long-term health effects:

- **Dermatitis**: inflammation of the skin. Look for redness, itching, swelling, and blisters.
- **Nervous system disorders**: you may experience fatigue, muscle shakes, memory loss, or reduced mental performance.
- **Damage to liver and kidneys**: chlorinated solvents can cause this.

Acute toxicity

Ico 9.1.6 Acute toxicity

Symbol: Skulls and crossbones

Can mean:

- Fatal if swallowed
- Fatal in contact with skin
- Fatal if inhaled
- Toxic if swallowed
- Toxic in contact with skin
- Toxic if inhaled

Examples of where we can find it:

- Pesticide, biocide, methanol

Examples of precautionary statements:

- Wash thoroughly after handling.
- Do not eat, drink or smoke when using this product.
- If swallowed: immediately call a POISON CENTER or a doctor/physician.
- Rinse mouth.
- Store in a closed container.
- Do not get in eyes, on skin, or on clothing.
- Wear protective gloves/protective clothing/eye protection/face protection.
- If on skin: gently wash with plenty of soap and water.
- Immediately remove/take off all contaminated clothing.
- Wash contaminated clothing before reuse.
- Do not breathe dust/fume/gas/mist/vapours/spray.
- Use outdoors or in a well-ventilated area only.
- Wear respiratory protection.
- If inhaled: Remove victim to fresh air and keep at rest in a position comfortable for breathing.
- Store locked up.

Health hazard/Hazardous to the ozone layer

Ico 9.1.7 Health hazard/Hazardous to the ozone layer

Symbol: Exclamation Mark

Can mean:

- May cause respiratory irritation.
- May cause drowsiness or dizziness.
- May cause an allergic skin reaction.
- Causes serious eye irritation.
- Causes skin irritation.
- Harmful if swallowed.
- Harmful in contact with skin.
- Harmful if inhaled.
- Harms public health and the environment by destroying ozone in the upper atmosphere.

Examples of where we can find it:

- Washing detergents, toilet cleaner, coolant fluid

Examples of precautionary statements:

- Avoid breathing dust/fume/gas/mist/vapours/spray.
- Use outdoors or in a well-ventilated area only.
- If inhaled: remove victim to fresh air and keep at rest in a position comfortable for breathing.
- If swallowed: call a POISON CENTER or a doctor/physician if you feel unwell.
- Wear protective gloves/protective clothing/eye protection/face protection.
- If on skin: wash with plenty of soap and water.
- If in eyes: rinse cautiously with water for several minutes. Remove contact lens, if present and easy to do. Continue rinsing.
- Do not eat, drink or smoke when using this product.

Serious health hazard

Symbol: Health hazard
Can mean:

Ico 9.1.8 Serious health hazard

- May be fatal if swallowed and enters airways.
- Causes damage to organs.
- May cause damage to organs.
- May damage fertility or the unborn child.
- Suspected of damaging fertility or the unborn child.
- May cause cancer.
- Suspected of causing cancer.
- May cause genetic defects.

- Suspected of causing genetic defects.
- May cause allergy or asthma symptoms or breathing difficulties if inhaled.

Examples of where we can find it:

- Turpentine, petrol, lamp oil

Examples of precautionary statements:

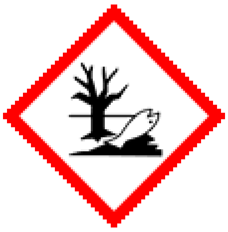
- If swallowed: immediately call a POISON CENTER or a doctor/physician.
- Do NOT induce vomiting.
- Store locked up.
- Do not breathe dust/fume/gas/mist/vapours/spray.
- Wash thoroughly after handling.
- Do not eat, drink or smoke when using this product.
- Get medical advice/attention if you feel unwell.
- If exposed: Call a POISON CENTER or doctor/physician.
- Obtain special instructions before use.
- Do not handle until all safety precautions have been read and understood.
- Use personal protective equipment as required.
- If exposed or concerned: Get medical advice/attention.
- Avoid breathing dust/fume/gas/mist/vapours/spray.
- In case of inadequate ventilation wear respiratory protection.
- If inhaled: If breathing is difficult, remove victim, bring to fresh air and keep at rest in a position comfortable for breathing.

Environmental hazard

The last group are environmental hazards that threaten or damage the environment, nature and water supplies. The corrosive sign is also part of the environmental hazard group.

Hazardous to the environment

Symbol: Environment



Ico 9.1.9 Hazardous to the environment

Can mean:

- Very toxic to aquatic life with long lasting effects
- Toxic to aquatic life with long lasting effects

Examples of where we can find it:

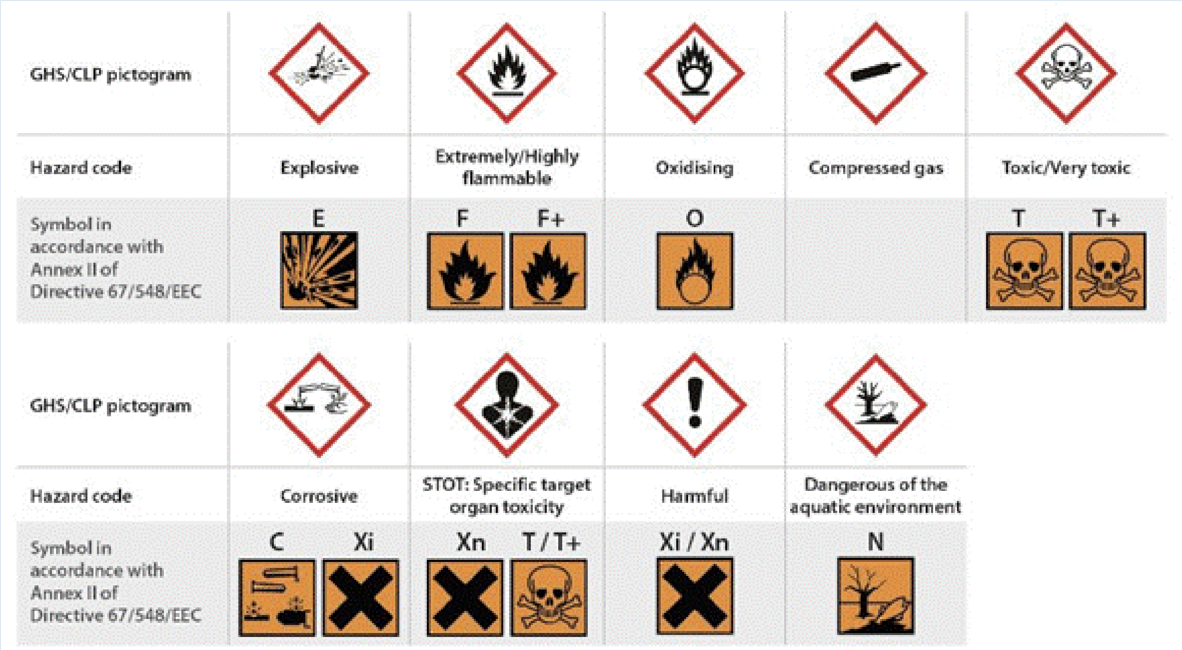
- Pesticides, biocides, petrol, turpentine

Examples of precautionary statements:

- Avoid release into the environment.
- Collect spillage.

Older symbols

Conversion table of new vs. old chemical hazard labels.



GHS/CLP pictogram					
Hazard code	Explosive	Extremely/Highly flammable	Oxidising	Compressed gas	Toxic/Very toxic
Symbol in accordance with Annex II of Directive 67/548/EEC	E	F F+	O		T T+

GHS/CLP pictogram				
Hazard code	Corrosive	STOT: Specific target organ toxicity	Harmful	Dangerous of the aquatic environment
Symbol in accordance with Annex II of Directive 67/548/EEC	C Xi	Xn T / T+	Xi / Xn	N

What you need to remember

- To have a first, general idea about the risks, all hazardous products are required to have one or more pictograms on their containers indicating the type of risk they pose.
- The pictograms are in the shape of a red diamond with a white background.
- These pictograms are part of the Globally Harmonized System of classification and labelling of chemicals (GHS).
- The pictogram is accompanied by a hazard statement describing the nature of the hazards.
- Precautionary statements give extra information on what precautions to take
- We make a distinction between:
- Physical hazards, that harm or damage the physical environment as well as the human body.
- Health hazards, harming the human body
- Environmental hazards that threaten or damage the environment, nature and water supplies.

Terms and definitions

- hazard statement
- precautionary statement
- product pictogram
- explosive
- flammable
- oxidising
- corrosive
- absorption
- inhalation
- ingestion
- injection
- irritation
- toxic

Rehearsal questions

09.01.01 Hazard pictograms are

a) red triangles with white text.
b) red diamonds with a white background.
c) orange with black pictures.

09.01.02 True/False

- A precautionary statement describes the nature of the hazards of a hazardous product.

09.01.03 True/False

- A hazard statement describes what you should do to work safely.

09.01.04 True/False

- A product with a physical hazard sign can harm or damage the physical environment as well as the human body.

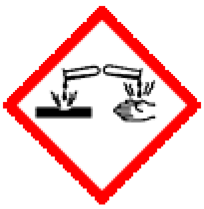
09.01.05 This symbol means

a) Explosive
b) Flammable
c) Oxidising

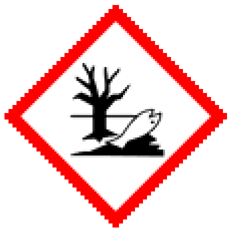
09.01.06 Match where you could find this

1. A poisonous drink
2. Paint stripper
3. A bottle that should not be emptied in a drain
4. Pyrotechnics


A


B


C


D

09.01.07 True/False

- A product with a health hazard sign only harms in the long run, but has no direct effects.

09.01.08 Which method does not cause health hazard

a) Absorption
b) Vision
c) Ingestion
d) Injection

9.2 Safety data sheets

Before you start, you should read Chapter 09.01 Risks and Labels of hazardous substances.

At the end of this block, you:

- Understand the purpose of a safety data sheet.
- Know where to find the information you need..

Safety data sheets provide the users of chemicals with the necessary information to help them protect human health and the environment. Safety data sheets are intended both for the **workers** who handle the chemicals and for those **responsible for safety**.

The safety data sheet contains more information than the product label on the container. It contains all the information you need to **work** with a product in a safe and sustainable way and to **be prepared** for possible incidents. It also contains information you need to give to medical staff when you call them in case of an emergency. Therefore, safety data sheets of all the products available on stage should be within reach.

The format of the safety data sheet is defined in the REACH Regulation. It is divided into 16 sections, and each section contains information on a specific topic or a specific user.

A safety data sheet contains the following 16 information sections:

Fig. 9.2.a reading

- Identification of the substance/mixture and of the company/undertaking
- Identification of the hazards
- Composition/information on ingredients
- First-aid measures
- Firefighting measures
- Accidental release measures
- Handling and storage
- Exposure controls/personal protection
- Physical and chemical properties
- Stability and reactivity
- Toxicological information
- Ecological information
- Considerations for disposal

- Transport information
- Regulatory information
- Other information

Below, we describe the different chapters in detail, with a focus on the information that is applicable on stage:

Identification of the substance/mixture and of the company/undertaking

This section not only identifies the product and the manufacturer, it also explains the intended use and indicates an emergency telephone number.

Identification of the hazards

The identification of the hazards contains the safety label and information on hazards and precautions to be taken. This information is presented in standardised numbered statements. The statements start with a code followed by a 3-digit number. Based on this number, you can find the sentence in your own language.

H statements contain hazard information, for example

- H223 – Flammable aerosol.
- H301 – Toxic if swallowed.
- H335 – May cause respiratory irritation.

P statements contain precautions that need to be taken, for example:

- P103 – Read label before use.
- P211 – Do not spray on an open flame or other ignition source.
- P251 – Pressurized container: Do not pierce or burn, even after use.
- P403 – Store in a well-ventilated place.

EUH statements refer to the earlier system of R and S sentences, in case there is no equivalent in the new version.

Composition/information on ingredients

This section contains technical information about the chemical composition.

First-aid measures

The first aid measures contain information about **symptoms**, about how to react as a **first responder** and about **medical treatment**. The first aid measures are written in a way that everyone should understand them. Example:

- General: In all cases of doubt, or when symptoms persist, seek medical attention. let an unconscious person ingest anything. If unconscious, place in recovery position and seek medical advice.
- Skin contact: Remove contaminated clothing and shoes. Wash skin thoroughly with soap and water or use recognised skin cleanser. Do NOT use solvents or thinners.

Firefighting measures

The firefighting measures contain information about the type of extinguisher to use and other useful information for firefighting. The section also contains information about the possible hazards arising from the chemical in case of fire.

Accidental release measures

This section contains information about what you and emergency responders should do in case of spillage. It provides you with information about how to protect yourself, your colleagues and the environment, but also about the methods and materials to contain the spill and to clean up.

Handling and storage

This section explains how to handle the product safely, how to store it and incompatibilities with other products in storage.

Exposure controls/personal protection

The exposure controls/personal protection section includes the use of personal protection equipment, hygiene precautions and collective measures.

Physical and chemical properties

The physical and chemical properties section gives information on the properties of the chemical substance or mixture (such as appearance, odour, pH, boiling point etc.) that are relevant to the classification and the hazards. In other words, on what the product looks like and how it behaves.)

Stability and reactivity

Describes under what conditions the product is stable and which incompatible materials would influence this stability. This section deals with hazardous reactions that could occur under certain conditions of uses, or if released into the environment; conditions to avoid; incompatible materials and hazardous decomposition products.

Toxicological information

This section is intended primarily for medical professionals, occupational health and safety professionals, and toxicologists, and informs about the technical aspects of toxicology or the product.

Ecological information

This section contains information on how the product can influence the environment and how to avoid this.

Considerations on disposal

Information on how the material, the contaminated tools, and the packaging have to be disposed of.

Transport information

Information about industrial transport, but also about transport within the premises. For example:

- Transport within user's premises: always transport in closed containers that are upright and secure. Ensure that people transporting the product know what to do in the event of an accident or spillage.

Regulatory information

This section contains information about regulations applying to this product or its use.

Other information

The last section includes technical information about the document, disclaimer, references, and advise on training.

What you need to remember

Safety data sheets provide the users of chemicals with the necessary information to help them protect human health and the environment.

Safety data sheets have a defined format and contain more information than the container labels.

The data sheet contains important information for an average user

- Identification of the hazards
- First-aid measures
- Firefighting measures
- Accidental release measures
- Handling and storage
- Exposure controls/personal protection
- Considerations for disposal
- Transport information

H statements contain hazard information

P statements contain precautions that need to be taken

Terms and definitions

- chemical
- safety data sheet
- H statements
- P statements

Rehearsal questions

09.02.01 A safety data sheet contains information about

a) the size of the container.
b) the type of the container.
c) the ecological measures to be taken.

09.02.02 True/False

- Safety data sheets provide the users of chemicals with the necessary information to help them applying different products.

09.02.03 A statement containing hazard information is a

a) P statement.
b) H statement.
c) R statement.

09.02.04 True/False

- A safety data sheet explains how to handle the product safely, how to store it and incompatibilities with other products in storage.

9.3 Storage of hazardous substances

Before you start, you should read the chapter 05.01 Fire theory.

At the end of this block, you:

- Understand the importance of storing hazardous products in a proper way.
- Understand the 5 basic rules for storing hazardous products.

Flammable liquids (maintenance products, oil, petrol, spirits, paints, flame gels, etc.), flammable gases (airosols, propane, butane, acytilane, oxygen, nitrogene, etc.), pyrotechnics, CO2 (Dry ice), etc. need to be stored, labelled and documented in a proper way.

Proper storage will **minimise the risks** of fire, explosion, health damage, and contamination of the environment.

Pic. 9.3.1 Chemical storage cabinet

Labelling and documenting

Before storing, all products need to have a label. This label ensures that we know exactly what product we are dealing with and what the risks are. If you make your own mix, or store a product in another container, you need to label this yourself.

The storage needs to be **inspected** on a regular base. The labels help to identify expired and obsolete products and to dispose of them. Disposal of unknown chemicals can be very expensive.

The storage space or cabinet is labelled with the hazard class of the content.

All products are recorded in an **inventory** that indicates where they are stored. The safety sheets of the products can be attached to this inventory. The inventory is available on the work spot as well as in a central place in case of emergency.

(for more details about labelling, safety sheets and inventory see chapter 9.01 and 9.02.)

Rules about recipients and containers

Some basic rules should be observed about the packages, recipients and containers with hazardous materials:

- The packages and containers should be sealed if they can emit air pollutants.
- Do not use packaging that may be mixed/confused and because of that cause damage.
- The packaging should withstand the substances stored in them.
- The packaging should withstand the environment in which they are placed.
- Check regularly that the containers do not leak.

5 basic rules about / for storage

A risk assessment will explain in detail exactly how a product, in combination with other products, in a specific situation needs to be stored. Clearly, keeping the storage clean and in good order is essential to be able to read the labels. The risk assessment is based on five basic rules:

Fig. 9.3.a Hazardous substances

Protection against ignition sources

Flammable products need to be protected against ignition sources. This can be an open flame, heat sources, sparks, smoking, and direct sunlight. In some cases the risk for static electricity requires attention too. These products need to be stored in a fireproof cabinet or storage space.

Protection against “unauthorized persons”

All hazardous products need to be stored in such a way that only “authorized persons” can access them. Authorized persons are persons informed and trained to handle the products in the storage. Locking the storage is the most common way to guarantee this.

Ventilation

If there is a risk of explosive fume mixtures, unpleasant smell or poisonous fumes, the storage needs to be ventilated.

Avoid combination of interfering products

Combining products can increase the risks of something going wrong. For example, bringing flammable and oxygenic (oxygen rich) products together will make the fire bigger as the oxygen feeds the flame. Other chemicals will react, creating toxic fumes or even explosions. Not only the stored products have to be separated, but possible combinations of spilled products also need to be avoided. The risk assessment will identify all harmful combinations and propose solutions for proper storing.

An example of this is the combination of linseed oil and fabric (which induces oxygen).

Spillage

A storage facility needs to foresee possible spillages and provide measures to keep these under control. Spillage containers under products avoid spreading of harmful products outside the storage. Spilling products in sinks, floor drains or storm drains can have disastrous consequences. Where needed, the organization of the spillage containers also avoids combination of spilled chemicals.

On tour

It can be necessary to take hazardous substances on tour for a production. Examples are specific cleaning products, gases, pyrotechnics etc. A **specific risk assessment** is made for these circumstances and is part of the communication with the receiving house or venue (what, where, how much, why,…). In all cases, the above basic rules need to be interpreted for this specific situation.

Extra measures can be taken to minimize the amount of product taken on tour and to ensure that products are not left unattended at any moment.

Storage of CO_2 (dry ice)

Dry ice or CO_2 ice is the solid (frozen) form of carbon dioxide. Dry ice sublimes at −78.5 °C. The gas is not toxic but replaces oxygen in the air. There is a risk for breathing problems. The ice should be stored in a sealed insulated box. The storage of the box should be ventilated. CO_2 gas is heavier than air. It will accumulate in low places like cellars. Extra attention has to be paid to the ventilation of these spaces.

Storage of Pyrotechnics

Pyrotechnics should be stored in a closed box or room to make sure they are shielded from unauthorised persons. Pyrotechnics should be stored in limited amounts. No more than what is needed for one performance should be stored on stage. The products should be left in their original package and out of reach from ignition sources, heat, fumes of chemicals, or moisture.

What you need to remember

- All hazardous products must be stored in an adapted cabinet or space.
- All hazardous products must be labelled.
- The storage space or cabinet must be labelled.
- An inventory of hazardous products, including the safety sheets must be available in case of emergency.
- 5 basic rules about / for storage
    - Protect against ignition sources
    - Protect against “unauthorized persons”
    - Ensure ventilation
    - Avoid combination of interfering products

Terms and definitions

- storage cabinet
- hazardous substance
- sealed
- ignition sources
- spillage

Rehearsal questions

09.03.01 True/False

- If products are kept in the same closet, they don't need to be labelled.

09.03.02 If there is a risk of explosive fume mixtures, the storage closet must be

a) ventilated.
b) closed off.
c) emptied.

09.03.03 True/False

- Flammable products need to be stored in a fireproof cabinet or storage space.

09.03.04 True/False

- Products that react with each other can be stored together in one cabinet.

09.03.05 True/False

- If you take hazardous chemicals on tour, you don't need a different risk assessment than in your workshop.

10 Fit up and rig performance equipment

To Fit up and rig performance equipment, you must:

Unload, hang, place and secure different types of temporary performance equipment on existing structures and on and around the stage floor.

This means you master following skills:

- Transports, places, moves, stacks and transports technical performance equipment and materials according to the needs during the fit up.
- Inspects the technical performance equipment visually for damage, wear and tear.
- Mounts and rigs technical performance equipment according to instructions and/or plans.
- Takes safety precautions when working at or below heights.
- Checks that technical performance equipment and objects can move freely during different operations when needed.
- Immobilizes technical performance equipment once in place.
- Secures technical performance equipment and accessories.
- Checks that all technical performance equipment is secured according to safety procedures.
- Takes action if something goes wrong or is unsafe.
- Reports if something is not performed according to the agreed procedures.

You master following knowledge:

- Principles of mechanics
- Identifying and checking technical performance equipment
- Suspension systems
- (Risks on stage)

You have following attitudes:

- Safety awareness
- Awareness of others behaviour
- Attention to movements around you

In the theatre and event sector, we hang a lot of equipment on support structures. We also build a lot of temporary constructions for our productions. We hang lights and sound equipment above people and we don't want anything to come falling down. We set up sets, stages and other complex shaped objects and we don't want any of those to flip over. The structures we build have to be stable and solid to walk on.

Surfaces and sets have to be dimensioned, designed, erected, supported, stiffened, suspended, ballasted, and anchored in such a way that they can absorb and transmit the **static and dynamic loads and forces** which occur when they are used as intended. These structures have to be stable at all times, including during set-up and strike. If they are walked upon, they must withstand the forces of an active person. When working outdoors wind, water, snow and ice will put extra forces to our sets and surfaces.

On a higher level, before we go on stage, **construction engineers** will take extra attention for safety regulations, maximum load-bearing capacity and structural stability when they design:

- stage platforms and sets to be walked on
- stage trucks and wagons
- grids and suspension systems
- fly lofts, galleries and spectator stands complies with the load-bearing capacity

We move a lot of stuff during the productions, sets, structures, sound and light equipment has to be set-up, moved or taken down. Keeping up **structural safety** requires someone having an overview of the whole set-up, therefore you will always work under supervision. This doesn't mean you have no responsibility, you are supposed to:

- **prepare** your work based on drawings and instructions
- work according **good practice** and procedures
- **check** your material, your work
- **warn** if you detect or foresee a problem
- listen well to given **instructions**

Here, we limit ourselves to the **hanging, placing, and rigging of technical performance equipment** like spotlights, sound equipment, video equipment, sets, etc. In other words, we work with existing suspension systems, we do not build the suspension system itself. This is the work of a rigger, who hangs trusses, motors, and other suspension systems, which requires specific skills.

In the following sections, we will explain what is expected from you.

Knowing what you are doing

Knowing what you are doing is always important, but when building constructions that can pose a risk, or hanging equipment above people's heads, knowing what you are doing becomes even more important. **Inform** yourself, **read** the instructions, guidelines and manuals, and listen to **directions**. Follow regular **training** and instruction sessions. **Ask** questions if in doubt, it is not a shame to ask something. It is a shame to do something you don't really understand.

Remember a suspension is as strong as it weakest part, **a chain is a strong as the weakest link**. The cause of an accident is often in a small detail. One forgotten bolt or fastener can endanger the whole construction.

Working below activities at height

When building a performance, a lot of work will happen at height. You have to **avoid** working under a (not yet secured) load or on the floor when colleagues are working above you. In reality it is not always possible to avoid this kind of activities completely or to fence off the area. Using the proper **PPE** helps to solve minor issues, but the PPEs do not reduce the risk, they only reduce the injuries. The most important thing is to **be aware!** You need to constantly pay attention to what is happening above you.

Working at height

Building sets or other constructions means you will work at height and you will use tools, bolts and nuts, etc. A special attention point, next to the standard procedures for working at height, is to constantly check that no **loose elements** are left behind on top of sets, etc. The fact you are constructing something means that the construction isn't finished yet. So you need to check at any moment if the construction is already **safe to walk on**, to lean on, to let it stand free, etc.

Fig. 9.3.a working at height

In many cases, you work together with several people, some standing on the floor below you. Be aware of the people below you. Check who is below you and that you do not endanger them with your actions. You need a **constant awareness of what is happening below you** and be aware of your supervisor giving you instructions.

Checking your equipment

Of course all the equipment and tools you use will have been checked when they were taken in use for the first time and on a regular base. This is done by specialised people. But there is a good chance that something happened with the equipment between the moment of the check and the moment you use it. Most equipment is used intensively under circumstances that can sometimes be harsh. Therefore, you need to **visually check** every single part you use for damage. This is a matter of constant awareness, more than of extensive procedures. When you start, you can use a checklist as a reminder, but after a while it becomes a habit to do a check every time you open a flight case and take the equipment out.

Obvious things to look at are:

- Steels with threads sticking out, kinks in steels or missing thimbles
- Damaged bolds for shackles
- Dents and humps/bends and cracks in trusses
- Deformation and stress damage of all kind of equipment

- Defective locks or fasteners on (scissor) risers
- Lose connections, like bolds loosened by vibration in transport
- Missing joints, hinges, eyes, attachment points for braces, lash lines pens, etc. for sets
- Faults or damage on constructions or sets
- Overdue periodic checks or expiring dates
- Check for moisture in cases or on equipment
- Wear and tear in general

When you find **faulty equipment** that can’t be repaired immediately and properly, you need to mark it according the habits or procedures of the place you work at or the company you work for. Some organisations use marks, others have a specific place or box to put equipment for repair.

You need to identify the proper equipment and be sure it is fit for the purpose. Understanding the labels and colour codes is a good help. Remember it is not sure that the label on the box corresponds with what is in the box. Sometimes there are small variations that are essential. Combining different brands can damage the equipment, for example using truss pins/cones from different brands or clamps that don't fit the pipe. This does not mean you have to be able to choose the equipment, but you should be able to **recognise and identify** what you take. When in doubt, ask your supervisor.

Attaching to suspension systems

Suspension systems are a general term for all kinds of constructions made to hang equipment on. You can think of fly bars, trusses, fixed bars or grids, scaffolding, traveller systems, etc. In the theatre and event sector, we will often use these systems to hang equipment **above the heads of the audience**, workers or performers. In no other sector you would be allowed to hang (temporary) loads above people. But for us, it is an essential part of our job.

Because of the extensive risks of hanging equipment above people, we need to take **extra measures**. A first safety provision is that we constantly check the **maximum allowed loads** on the suspension systems. Every suspension system has a calculated safe working load. This safe working load includes a **safety factor** for extra safety. Knowing the maximum allowed load doesn't mean you are allowed to hang this load wherever on the suspension system. A load that is distributed over a whole system will have less impact than a load that hangs on one point. This is why you will always work under supervision of an experienced operator who will give you instructions.

One of the most important measures is that we use a **double security**. First of all, we fix things properly so they can't move or fall. To avoid that if one system fails, things would come down, we use a second system that will take over when the first one fails. This can be, for example, a safety cable. If the bolt or the hook of a spotlight fails, it will be stopped by the safety cable.

All equipment should have a **marked connection point** for the safety cable. Do not use handles or other uncertified points to connect the cable. If no connection points are available, ask your supervisor about a safe procedure.


Fig. 9.3.b hanging equipment

The **quick-connector** of the safety cable must be protected against unintended opening. Be sure you close it properly every time. To minimise the dynamic force in case of a fall, we need to keep the safety cable as **short** as possible.

Check the safety cables visually every time you use them. Safety cables should be rated for the object that needs to be secured. They are designed to withstand the force of a falling object once. If they have encountered a fall, they should be replaced. Safety cables should **not be confused with steels** that are made to hang equipment. They should never be used for this purpose.

When you attach equipment on a pipe or a truss, always make sure the clamp is properly **tightened** and the **safety cable** is attached with enough space/slack to turn later, before you leave the location. This is the best way to avoid that things go up without a proper safety. Check all safety devices again when the work is finished and before the suspension system is allowed to go up or before you go down from a grid.

When hanging equipment, you always need to take care not to damage temporary or permanent electrical cabling in the pipes. A cable should never be in a clamp.

The procedure to hang equipment depends on the suspension system. We can distinguish four different situations:

A fixed grid system

Fixed systems are used a lot in smaller venues. The drawback is that it often happens that you can't hang your equipment where you would like it. Spaces between bars can be from 1 up to 2 meters. When you attach equipment on a fixed system, like a fixed grid, fixed pipes or fixed trusses, you need to go up with the equipment. There are different methods to do this, but the important part is that you **avoid carrying the weight** of the equipment. Use a rope with a pulley on a fixed point to lift the equipment. Working from a scaffold or MEWP is preferred to the use of a ladder. Hang the equipment and **fasten** the clamps before anything else. **Secure** the equipment with a safety cable immediately. Before you go up, remember to take tape or T-fix like bands to **secure cables**. And, of course, use a **lanyard** for the tools that you take up.

Working bridges and surfaces

Smaller and medium venues often have working bridges or walking surfaces like tension grids. Even if you are working on a fixed surface, you are still working at height and the risks and issues of a fixed grid stay the same.

Counter weight systems

Counter weight systems are used a lot in bigger theatres above the stage. This is a fast way of working and it avoids a lot of going up. In these systems, the pipes can be close to each other, so you can usually hang your equipment where it is wanted. A counter weight system has to be **in balance** to be safe. The brakes are only meant to hold the weight difference between two weights. The brakes are not made to hold the weight of the equipment. When an empty bar is lowered, you can safely attach equipment. There is no counter weight loaded yet, so the weight on the ground side is higher than the counterweight. Once all the equipment is hung, the operator will load the counter weights to balance the system. After this, the fly bar can go up.

But in the other direction, you will have to **wait till the counterweight is unloaded**, before you can remove the equipment. Otherwise, the counterweight would be heavier than the load and could pull the fly bar up if the brake would slip. The operator will give clearance when you are allowed to detach the equipment.

Manual fly bar operations have to be guided by a trained operator. This operator will tell you when you are allowed to attach or detach equipment. It is very important to have good and clear

communication with the operator to avoid misunderstandings. When lowering the fly bars, the operator will always warn it is moving.

Powered systems

Powered systems do not need counterweights. They are designed to lift the weight using motors, hoists or hydraulics. This means we don't have to worry about balance. We can hang or remove equipment when we want, within the load limits of the system.

The **operator** will warn when the system comes down and when it is down and stable, we can hang the equipment. When that is finished, the operator will check if all is ready and secured and the system goes up. Be sure you checked everything **before the system goes up**. Ask the operator to wait if you have the feeling that something is not OK.

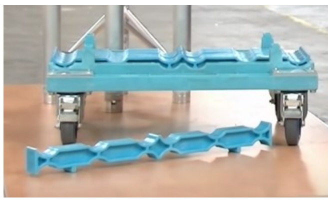
Truss systems

Truss systems are never permanent or part of the building. They are often used outside or in temporary spaces. The trusses are mounted and hung on chain hoists. Often trusses are also put on baseplates as a standing construction or with motors as a ground support. Hanging truss and making truss systems stand is work for a specialist, a **rigger**. Too many risks are involved when setting up or hanging truss, therefore it is not part of your job.

Mounting trusses will often be the first thing to do once the hoists are ready and before you can start hanging equipment or sets. Trusses are more fragile than they look. They are made out of aluminium that easily deforms, the connections have to fit perfectly to ensure maximum strength and the hinges need to stay aligned to avoid unnecessary forces on the construction.

Trusses are often damaged during transport. When they move and shake during transport, when they hit each other, when they are dragged or dropped, when they bump against other stuff, when they are strapped too strong, or moved with sharp edged transport means, they will get deformations. The aluminium rods between the main pipes are most vulnerable. In most cases this means the structural integrity is lost and the truss has to be discarded. **Careful use and using proper transport equipment** like truss dollies and truss carriers helps to prevent damage.

Pic. 9.3.1 truss carrier



Pic. 9.3.2 truss dolly

There are different types of truss connections (pipe, conical, pin-fork) and development of connections is still in progress, but some common rules apply. Before connecting, the different parts of the truss should be **in line and on the same level**. Ideally the trusses are **supported** to level them on the ground, so they don't get damaged and you have room to make the connection. Bumps or an uneven underground will make it difficult to make proper connections.

The connecting parts should be **clean and undamaged**, dirt or damage on the connectors will also damage their counterpart. In normal circumstances, the connections can be made without tools. If this doesn't work, first check what is wrong before forcing the connectors into each other. Probably moving the truss at the end, to line it up, will help to bring the parts in place. Not all connectors are symmetrical, in some cases the pens can only enter from one side. If for some reason you do need to put more force, never use a steel hammer. The steel is harder than the connectors and will damage them. **Nylon or brass hammers** can be used as they are softer than the connectors. Once everything is in place, secure the pens with safety clips or, if it is a permanent connection, with threaded pen.

At the moment the truss is connected, it can be connected to the chain hoist. This is done with round slings, (covered) steels or lifting brackets. Making this connection is specialists' work, and there always needs to be someone supervising you.

When the truss is ready, you can start hanging equipment or sets. We will try to avoid using steel accessories to hang object on a truss. A steel clamp could **damage** the aluminium.

Hanging sets

When we need to attach sets or other objects to suspension systems, we need to avoid that the pipes, bars or trusses are damaged by the connection. You should always use a clamp or a device that is made to fit the pipe to attach a chain or a steel. Laying a steel or a chain directly around the pipe can damage the pipe as well as the steel.

All the equipment used to connect the steel to the pipe should be **certified and load rated**. Remember the attachment is only as strong as the weakest part!

The division of the load on the pipe or truss must be taken into account. The truss has to stay in balance and the load on one point is limited.

When things start moving

Once everything is rigged and connected, the suspension systems will go up. At that moment, everyone should go away from the area under the fly bar or truss. **The risk is a lot higher when the system is moving.** It is hard for an operator to have a full overview of all the moving parts and the elements that surround them. You can help by checking if cables have enough slack to move, if the bars can pass between the other elements in the fly tower, if nothing gets stuck, etc.

A fly bar or a truss should always stay under its **suspension points**. In some cases, for example when a high, flat piece has to be lifted from the ground, it needs to be guided to be sure the bar stays in place. This is a complex operation, led by the operator. Once the object is hanging freely, everyone should get out of the way.

Ground constructions

Of course, we also build equipment on the floor. This can be risers, stands or tripods, sets, etc. A general attention point is that these constructions can be **unstable** when you are building them. Once they are ready, and they have been built according the instructions, they will probably be fine. This means that **during the setup**, you need to pay extra attention and for example secure them against use until they are finished.

Temporary risers, balconies, audience platforms, or staircases have to be connected to each other, so they become a stable platform, without any **open joints**. Most systems have specific clamps for this. Just like any other floor, they should be even and free of splinters. Floor coverings have to be secured against **slipping**. When people have to walk on the platform, the platform should have **railings**. When chairs are put on the platform, there should be a provision to avoid the feet of the chairs to slide off. If a surface looks like a riser, but has no load bearing capacity, it has to be fenced off or secured in another way. Larger constructions like grand stands will be built under supervision of specialists

Tripods, spot ladders, … that carry equipment have a high risk of tipping over. The **gravity point** of the load should always be kept within the ground surface of the tripod. This is especially tricky when using T-bars. Tripods have to be used within the limits of their **maximum load rating**.

Next to the smaller ground constructions, you can have bigger truss ground constructions, **a ground support**. These will be built by specialists. They can be a fixed construction, or a self-support with a moving grid. If you assist in building, listen carefully to the instructions of the supervising person.

Sets

Building sets is a very wide area of work. Sets can be flats, but also 3D constructions. The shapes are mostly unique and need specific handling. But some general issues always come back:

- Setting up sets is a team effort, listen carefully to the **instructions** and adapt to your colleagues.
- Most sets have marks that have to match in order to connect them properly. Specific devices like half-hinges or loose-pin backflaps are used to make the connections. To stabilise the sets, counter weights or sand bags are used.
- Rising flat sets is often done by "**walking up**" the set. The set lies on the floor and one end is lifted and pushed up while walking to the other end. You have to avoid that the part that stays on the ground starts sliding, ideally some extra people put their **feet** against the other end. A tricky moment is when the flat is completely up. Due the speed, it could flip over to the other side. Once the flat is up, it is positioned and secured. It is important that enough people keep it **in balance** until everything is safe.
- To take down a set, flats can fall in a controlled way. The air resistance will limit the speed.
- To mount heavy elements, you need enough people to handle the weight and the complexity of the structure. It is not always possible to make sets so they are easy to handle. Sets often have surfaces with a limited grip or parts that are fragile. This means you need extra hands or you have to use tools and machines (hooks, forklift, fly bars, …) to help. Don't forget to wear your **PPE**!
- When building sets on moving constructions like stage wagons, elevators, turntables, etc. we need to take into account the **dynamic forces** that will impact the set. A second element is that the moving construction itself needs a **clean and free surface** to move on. Cables, dirt or small parts can damage the wheels or make them get stuck. When moving, everyone in the area should be **warned** and the passage has to be **checked**, not only on the floor, but also at **height**.
- A simple check at the end is to see if there are any leftover parts. Except for spare parts, all elements should be used.

Securing during transport and storage

When we are transporting or storing equipment or sets, we have to be sure things can't fall during the transport or when left unattended. Otherwise, they could start moving, get damaged, hurt people or even influence the driving of the truck. We cannot stress it enough, know what you are doing! For instance, do not put loose elements on a flight case when unloading. Another example is to always use the brakes of flight cases and chariots when you store them.

Equipment and sets have to be **stacked** and tipped properly in a truck and **secured** with ratchet straps or cargo load bars. Cases or chariots on wheels should be tipped, put on blocks or secured in another way. For heavy loads the brakes are often not strong enough, so extra measures must be taken.

Chariots have to be loaded in such a way that nothing can fall of. The load has to be **balanced** to avoid that the chariot tips over.

Temporary storage, for example on side stages during a performance, makes it difficult to secure equipment. You need to be able to grab everything you need fast, which also means it can fall unexpectedly, especially with uninstructed people around and in difficult lighting conditions.

Check, check, check

We can't stress enough that when working on stage, you need a **permanent alertness**. Double checking has to become a second nature. Checking is a continuous process. Every time a situation changes, every time when something is finished, every time when something goes up, you should check it. Ideally everything is checked by yourself and by a colleague or supervisor. If you are the one that has changed a situation, do not forget to **inform** your colleagues or your supervisor. Remember that most accidents start with a small detail, a small thing missed during build-up, a clamp that is not properly fixed, a bolt that is forgotten, a tool that is left behind,…

Terms and definitions

- secondary safety
- temporary constructions
- grids and suspension systems
- suspension point
- fly lofts
- static and dynamic loads
- dynamic forces
- scissor risers
- shackle
- fly bars
- trusses
- fixed bars
- grid
- scaffolding
- counter weight system
- truss system
- ground construction
- ground support
- truss dolly
- tripod
- chariot
- performance equipment
- grid
- tension grid
- structural safety
- suspension system
- steel
- safety cable
- grandstand
- marked connection point
- quick connector
- maximum allowed loads
- safety factor

10.1 Principles of mechanics

At the end of this block, you:

- Understand the concept of forces.
- Know the basics about static and dynamic forces.
- Understand the concept of safety factors.
- Understand the concept of load limits.
- Understand the difference between point load and distributed load.

When we hang objects or put them on surfaces, this results in forces on the supporting structures. These structures can either be hanging positions or floors. We have to ensure that the structures can hold these forces in a safe way. Therefore, you have to understand the principles of mechanics, static and dynamic forces and the concepts of load limits and safety factors. The calculation of structures is based on strength theory. It is specialist work and is not discussed here.

In the science of mechanics, we define a force as "any interaction that, when unopposed, will change the motion of an object". In other words, when we put a force to an object, it will move except if it is stopped by an opposing force.

Example:

- When I push a chariot, it will move in the direction I push it. But once the chariot reaches the wall, it will stop. The wall will create an **opposing force**.
- When I put a box on the floor, it will be stopped by the surface it is on.
- When I hang a spotlight on a bar, the bar will create an opposing force to the gravity that tries to make the object fall. The force created by the hung spotlight may cause the pipe to bend before **both forces are in balance**.

A force can **increase or decrease the speed** of an object. It can also create a **torque**, a change in rotational speed.

Static and dynamic forces

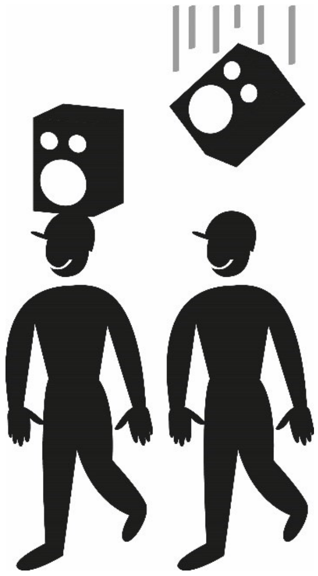


Fig. 10.1.a Static vs. dynamic

A **static force** is the force applied by a static weight on a fixed point (without movement or acceleration). When force and counter force are in balance, we say the force is a static force.

Example

- If you put your hand on a table and you put a weight of 5 kg on it, the weight will cause a static force to your hand.
- If you hang a spotlight on a fixed bar, the spotlight will cause a static force to the bar.

A **dynamic force** is the force applied by a weight on a point when it changes speed. The force takes into account the forces caused by acceleration or deceleration.

Example

- If you put your hand on a table and you drop a weight of 5 kg on it from 1 meter, the weight will cause a dynamic force to your hand. This force is the combination of the speed of the weight caused by gravity and the deceleration caused by your hand stopping it. The force will be a lot higher than the static force caused by the same weight.
- If you lower a spotlight with a rope, the spotlight will cause a dynamic force when you stop it.

We need to understand the different forces to be able to calculate the structures we use to hang or put things on. This is called **strength calculation** and is based on strength theory. Based on strength theory we can calculate if our structures and floor surfaces can withstand the applied forces in a safe way, without deformation or destruction.

Because we need to take dynamic forces into account, we cannot use weight in kg as a parameter to calculate the strength of structures. To describe the force we use the unit "Newton" (N). To give you an idea of the value a **Newton** represents, we give the relation between the weight in kg and the static force a load will apply on a structure.

1kg = 9,81N = 0,01kN ≈ 0,01kN

100kg = 981N = 0,981kN ≈ 1kN

1000kg = 1t = 9.810N = 9,81 kN ≈ 10kN

Even if we mostly use static force to simplify the calculation, you have to realise that in most cases, the forces are higher in reality because of the influence of the dynamics. In the following text we will use only the static force.

Gravity

Gravity can be described as a force, caused by the magnetic field of the earth that pulls objects down to the centre of earth or the surface that is in between the centre of the earth and the object. In other words, gravity keeps us on the ground and therefore we do not float around in space.

Centre of gravity

Every object or combination of objects that are fitted together has a centre of gravity. This is the point around which an object's weight is evenly balanced. The centre of gravity is the (imaginary) point where the **resultant of the mass of an object** is situated.

When an object is standing, the gravity force will pull the object down towards the gravity centre to the earth. The object will put a **force on the surface** it is standing on. When an object is hanging, it will move until the gravity point is **directly below the attachment point**. The object will put a force on the suspension construction. When an object is attached at its gravity point, it will remain in **equilibrium** in any position.

Example:

- In your body the centre of gravity is somewhere above your belly. When you stand, the gravity force will pull you downwards to the ground on this point. When you hang, you will swing until you are stable under your attachment point.

Why do things fall over?

Objects fall over when their gravity point is **outside their support area**. In reality, there is also an influence of other forces like the force created by speed, but we only look at the static situation here.

Example:

- When you stand straight up with two feet close together, your gravity point is above and inside the support surface between your two feet. If you bend to a side without moving your hips, there is a moment you fall over. This is the moment your gravity point gets outside your feet surface. When you move your feet apart from each other now, the surface becomes larger, you can bend a lot further to the side now. In real life, we compensate our gravity point permanently. When we bend forward, we compensate by moving our hips backwords. When we reach out, we move one leg in the other direction. This is how we keep ourselves in balance.
- A tripod will be as stable as possible if the legs are out on their maximum position and the gravity point of the load is within the surface between the legs.

If we want objects to stand stable, we have to be sure their centre of gravity stays **within their support area**. When we combine objects, by fitting them together, we need to take into account the resultant of the different centres of gravity.

Example:

- When you reach out one arm, your centre of gravity will still be within the support surface of your feet. But when you take a heavy object in my hand, you will probably fall over if you don't compensate.
- When you hang a spotlight on one side of a T-bar on a tripod, you change the centre of gravity of the whole construction and the tripod will fall over.

To keep objects standing stable, we can compensate the centre of gravity or we can enlarge the support area.

Example:

- The outriggers of a scaffolding will enlarge the support area
- A T-bar with a spotlight on each side will compensate the forces of each single spotlight.

Low vs high centres of gravity

The closer the centre of gravity is to the supporting area, the more difficult it is to bring it out of the surface area. A low object will need to be tipped in a large **angle** to get out of the area, while a thin high object will only need a very small angle to get out of the support area.

Example:

- A pipe lying on the floor will be very stable, the centre of gravity is low and the surface is large. But a pipe standing up only needs a small movement to fall over, the centre of gravity is high and the surface is small.
- A spotlight on a floor stand will be more stable than a spotlight on a high tripod.

Fig. 10.1.b Juggling with the centre of gravity

This also means that if we lower the centre of gravity, we make objects more stable.

Example:

- When we put a counter weight on the feet of a tripod, it will be more difficult to tip it over.

Load limits and safety factors

When we are looking into the strength of a construction, we want to know what objects we can hang or put on it. We want to know what the maximum allowed load of the construction is. A load is everything that puts a force on a construction.

If you set up or rig equipment, this load (the mass), which hangs to the construction, applies a force due to the gravity. We need to be sure that the construction can hold these forces. Therefore an engineer will calculate how much force a construction can hold safely. Based on this calculation, we can check if we work within **the safe limits of the construction**.

Example:

- The max. load of a riser is 250kg/ SQM = 2,5 kN/ SQM.
- If you place a moderator with a chair at such an riser, you work within the limits. The moderator has a weight of 80kg and the chair 3kg. This will apply a force of 0,83 kN on the riser.
- But if you place a car with a weight of 3.000kg = 3t = 30 KN the acceptable load of 2,5KN/SQM is not enough. Each wheel will apply a force of 7,5 kN on the a square meter of the riser. There is a good chance that something goes wrong.

Breaking strength or ultimate strength

The engineer that calculates the strength of the constructions uses values given by the manufacturer. One of the values a manufacturer will provide is the breaking strength or ultimate strength. This value is the result of tests under laboratory conditions. It is the **average force needed to break** the product when it is new. It will be clear that this is not a value we can use on the stage. When construction parts are used or when they age, the strength will lower. And a value defining when something breaks means we have no margin for error.

Fig. 10.1.c breaking strength

Safety Factor or working coefficient

To be sure we have enough margin for safety, we calculate how much stronger we want a construction to be, to be sure its structural integrity remains under our working circumstances. The value we use for this is called the safety factor, sometimes also referred to as design factor. The Safety Factor (SF) is a term describing the **load carrying capacity of a system beyond the expected or actual loads**. We build systems purposefully much stronger than needed for normal usage to allow for emergency situations, unexpected loads, misuse, or degradation (reliability).

Depending on the manufacturer's information, different calculations need to be made to adapt the values to the concrete situation on stage. One of the elements influencing the safety factor is the fact that we hang loads over people. In this case, the safety factor is doubled (x2) because of the high risks.

- When the **load-bearing capacity** values for holding loads **above people** have been given, we can use the structure in accordance with the manufacturer's instructions. The safety factor for hanging above people is already included. In the future, we will refer to these values as **ELL** (Entertainment Load Limit)
- When the **minimum breaking load** is specified, this value must be divided by the required operating coefficient (the normal safety factor x the safety factor above people) in order to obtain the maximum permissible load capacity.
- If the **load-bearing capacity** (e.g. Working Load Limit, **WLL**) is specified, this applies to normal lifting situations but not above people. In performance environments this work equipment may be loaded with a maximum of half of this value. This is because we double the safety factor for loads hanging above people.

The table below gives the safety factors for different equipment for the two situations.

- No persons under the load, where the operating coefficient is given by the Directive 2006/42/EC (Machinery Directive)
- Persons under the load, where the operating coefficient is doubled to achieve personal safety. In Germany this is done according to DGUV regulation 17 and 18.

	No persons under the load	Above people
Wire ropes	5	10
Round slings with wire rope core	5	10
Round slings and slings made of man-made fibres	7	14
sling chains	4	8
Shackles according to DIN EN 13889:2009-02	5	10
Other metal elements in the load strand	4	8

dia. 10.1.1 Safety factors under different conditions

Example:

A wire rope has a breaking strength of 100 N (10kg), specified by the manufacturer.

- If I want to lift something with this rope, I have to divide the breaking load with the safety factor (no persons under load). I will be allowed to lift 20N (2kg).
- If I want to lift something above people, I have to divide the breaking load with the safety factor (above people). I will be allowed to lift 10N (1kg).

If we turn things around:

- If I want to lift 10 kg (100 N), I need a shackle
  - with a breaking strength of 100 N x safety factor 10 = 1000N (100 kg) to hang above people.
  - with a breaking strength of 100 N x safety factor 5 = 500 N (50 kg) if we don't use it above people.
  - with a WLL of 100N (10 kg) if we don't use it above people.
  - with a WLL of 200N (20kg) if we use it above people.
  - with a load-bearing capacity for loads above people of 100N (10 kg) if we use it above people.

Working Load Limit (WLL)

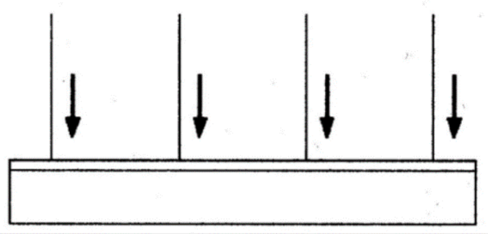
In most cases, a manufacturer of specialised equipment like trusses will indicate a Working Load Limit (WLL) for the equipment. The Working Load Limit is the maximum load that is allowed to be applied to the product, even when the product is new and the load is evenly spread. This is a value that you should never exceed!

WLL and SWL are abbreviated terms commonly used in the field of engineering. "WLL" stands for "working load limit" while "SWL" stands for "safe working load." The main difference between safe working load from working load limit is that "SWL" is the older term. Today, SWL is not used anymore because it has been completely replaced by the term WLL.

Point load and distributed load

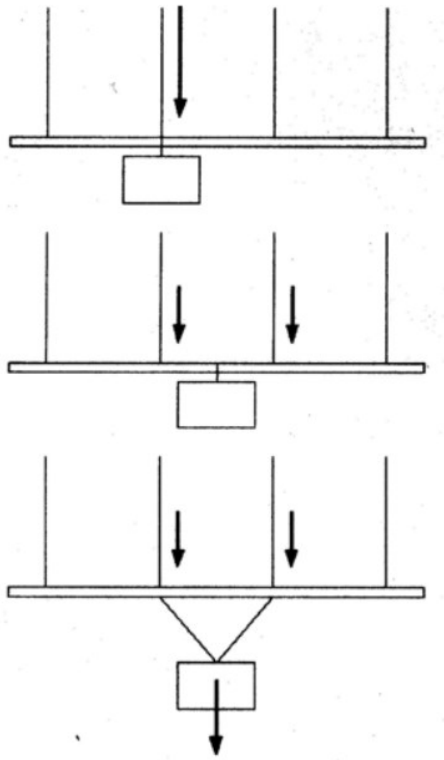
The given value for the maximum load on a fly bar or truss usually represents the **distributed load**. In other words, the load that will apply an equal force on the structure. This means we can't hang this load wherever we want on the structure. We have to distribute it over the whole length.

For example, a curtain will apply a distributed load on a fly bar. The load will be spread evenly over the different support cables. (the arrows represent forces)



Pic. 10.1.1 distributed load

When we attach the whole load at one point, we call this a **point load**, the force will be applied to only one or two support cables. When it is applied to two cables, it will also put a force on the pipe between the cables. This means parts of the structure will receive a force that is a lot higher than foreseen in the calculations. We will have to **limit the load**, based on specific calculations. To minimise the force on the pipe, we can use a bridle that brings the force directly to the support wires.



Pic. 10.1.2 Point load

The same applies when we work on a **floor** with a maximum load expressed in N/SQM. If we are allowed to use a load of 2.5 kN/SQM this does not mean we can put this force on one point of the floor. We will have to limit the load or use for example spreader plates to divide the load over the whole square meter.

Where does the term "MECHANICS" come from?

The term "mechanics" comes from Greek. In ancient Greece, the word "mechanics" meant as much as the art of inventing and building machines, which were mainly tools and war machines, but also all artificially made tools, such as scales, scopes,… The Greeks believed that mechanics worked against nature, for mechanics had made it possible for things that otherwise seemed impossible to happen. For instance, an actor who portrayed a god hovered from heaven on the stage thanks to the so-called Deus ex Machina, the god from the machine. He was able to deal with such unbelievable things with mechanics. That was the art of overriding nature to the Greeks. Mechanics was the knowledge to create effects and movements which the Greeks did not find in nature.

Source: K. Pichol; Was ist Was; Band 046; Mechanik; 05-2017

SI units

To calculate the forces, we use the SI Units. The basic SI units are:

- Metre [m] - the length
- Kilogram [kg] - the mass
- Second [s] - the time

The force [F] you need to accelerate a mass is the product of the mass [m] and the acceleration [a]. This is Newton's second law.

F = m * a

Mr. Newton (1643 -1727) defined the unit of acceleration as m/s2. The unit of force is called Newton [N]

N = kg * m/s2 = kgm/ s2

1 Newton [N] is the same force [F] you apply to a body of 1kg with an acceleration of 1m/s2.

1N = 1 kgm/s2

A specific force is the force due to gravity. If a body fall down to earth, this happens with the gravity acceleration g.

g = 9,81 m/s2.

What you need to remember

- When we put a force to an object, it will move except if it is stopped by an opposing force.
- A static force is the force applied by a static weight on a fixed point.
- A dynamic force is the force applied by a weight on a point when it changes speed.
- Gravity is a force, caused by the magnetic field of the earth.
- The centre of gravity is the point around which an objects weight is evenly balanced.
- Objects fall over when their gravity point is outside their support area.
- The closer the centre of gravity is to the supporting area, the more difficult it is to bring it out of the surface area.
- The safety factor (SF) is a term describing the load carrying capacity of a system beyond the expected or actual loads.
- The Working Load Limit is the maximum load that is allowed to be applied to the product, even when the product is new and when the load is evenly spread.
- A distributed load applies an equal force on the whole structure.
- A point load is a load that applies a force at one point.

Terms and definitions

- force
- static force
- dynamic force
- safety factor
- load limit
- point load
- distributed load
- torque
- acceleration
- strength calculation
- Newton (N)
- gravity
- centre of gravity
- equilibrium
- support area
- load
- breaking strength
- load-bearing capacity
- Working Load Limit (WLL)
- Safe Working Load (SWL)
- Entertainment Load Limit (ELL)
- opposing force

Rehearsal questions

10.01.01 An object hanging on a fixed bar causes

a) a static force.
b) a dynamic force.
c) no force at all.

10.01.02 Stopping a rolling wagon causes a

a) a static force.
b) a dynamic force.
c) no force at all.

10.01.03 When an object is attached in its gravity point, the object will

a) move.
b) Rotate.
c) remain in equilibrium in every position.

10.01.04 When an object is hanging on a fixed point, it will

a) move until it reaches the ground.
b) move until its gravity point is under the hanging point.
c) move until its gravity point is away from the hanging point.

10.01.05 When you move the gravity point of an object outside of the supporting area of the object

a) the object returns to its original position.
b) the object will be stable.
c) the object will fall over.

10.01.06 To make an object more stable, you can

a) make the supporting area smaller.
b) make the gravity point of the object higher.
c) move the gravity point to the centre of the supporting area.

10.01.07 Which object is more likely to tip over

a) an object with a low gravity point.
b) a light object.
c) an object with a high gravity point.

10.01.08 The ultimate strength is

a) the maximum load that can be safely applied.
b) the force needed to make the suspension fail.
c) the maximum load in performance conditions.

10.01.09 The safety factor (in entertainment applications) is

a) the relation between load bearing capacity and minimum breaking strength.
b) the relation between load bearing capacity and WLL.
c) the relation between the applied force at the attachment point and the force at the gravity point of the object.

10.01.10 When working above people, the safety factor

a) stays the same.
b) is halved.
c) is doubled.

10.01.11 When the maximum load of a fly bar and a load is equal,

a) you can hang the load at any position.
b) you need to distribute the load.
c) you have to hang the load between two attachment points.

10.01.12 If you hang a load only at one point of a construction with a given maximum load

a) you are allowed to increase the load you hang.
b) you have to decrease the load you hang.
c) It doesn't matter.

10.2 Identifying and checking technical performance equipment

At the end of this block, you:

- Identify technical performance equipment and accessories.
- Know what to check for visual damage.
- Recognise different identifiers of equipment.

We use a lot of devices and tools to link and connect our equipment to the suspension systems or points. You need to be able to **Identify and visually check** the devices you are manipulating or working with, even if you are not responsible to choose devices or methods.

Here, we limit ourselves to basic equipment and devices that are commonly used in theatre, events and entertainment. More concretely, we look into:

- Clamps
- Steel cables and safety cables
- Round slings
- Chains and hooks
- Shackles and carabiners
- Ropes

To be able to work safe, the first thing is to **recognise** the different types of devices. Some look quite similar and it is easy to confuse them. Using wrong devices could be dangerous, especially in rigging, where safety depends on the weakest element and each device has specific safety requirements.

To get a better understanding, it helps to have an idea of what the devices are used for and how we handle them. Without going into detail, we will give an overview of the most important issues later.

For devices that are important for safety, you are expected to check **for visual faults** and labels when you handle devices. If you are not sure whether something is safe, you are supposed to report this to a responsible person. This check is different from the **initial or periodic inspections** that are required by law and conducted by specialised people.

Identification

To know the exact properties of some devices and to be able to follow up periodic safety checks, we need to be able to identify each individual device. Most safety-critical devices will have a **label** that will give you information on:

- What the load limits are
- When the last periodic check was and/or what the expiring date is
- What the unique identifier is
- Who the manufacturer is etc.

Sometimes the label is (partly) replaced by other means serving the same purpose. For example:

- Colour coding for periodic checks
- Engraved codes in the body
- Tags to mark not to use the devices or to mark failure

These codes can differ depending region, company, sub-sector or tradition. So it is important to check what marks apply in the spot you work at.

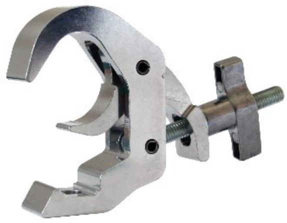
Clamps

A clamp in stage rigging terminology is a device that is used to hang equipment such as spotlights, speakers and projectors, to connect steel cables to fly bars or trusses and to connect pipes together in different ways. The clamp fits round a pipe and is fixed by tensioning a bolt.

Clamps will differ depending on the proposed use, the material they are made of, the way they attach, the work load limit and the size of the pipe they are made for. The **material** is mostly steel or aluminium. Steel clamps are used to fit on (steel) fly bars or scaffolding (we call them scaffold clamps). Aluminium clamps are made for truss or aluminium pipes. Steel clamps on aluminium would damage the pipes. Most clamps in theatre, entertainment and events are made for a **pipe size** of 48 – 50 mm, as this is the standard in the sector.

Most common clamps are:

- Spot clamps or **G clamps,** Trigger and quick trigger clamps used for hanging spotlights on bars. In general, they have a limited WLL.
- **C clamps**, used to hang a pipe under another at a certain distance. For example to hang a six bar under a fly bar.
- **Eye clamps** are used to hang a something with a shackle on a pipe.
- **Fly bar clamp** is used to connect steels and chains on fly bars.
- **Fixed clamps** exist in 3 main angles. 90° to make a straight angle, 180° and 360° to connect two parallel pipes. The difference between 180° and 360° is the position of the bolts, that are at the same side for 360° and at the opposite side for 180°.
- **Swivel clamps** are clamps that can turn to connect pipes in different angles.

Clamp types	Steel	Aluminium
Spot clamp	 Pic. 10.2.1 Spot clamp	
Trigger clamp		 Pic. 10.2.2 Trigger clamp
Quick trigger		 Pic. 10.2.3 Quick trigger clamp
C clamp		 Pic. 10.2.4 C clamp

Eye clamp	 *Pic. 10.2.5 steel eye clamp*	 *Pic. 10.2.6 Aluminium eye clamp*
Fly bar clamp	 *Pic. 10.2.7 Fly bar clamp*	
Fixed	 *Pic. 10.2.8 Steel fixed pipe clamp*	 *Pic. 10.2.9 Aluminium fixed pipe clamp*
Swivel	 *Pic. 10.2.10 Steel swivel clamp*	 *Pic. 10.2.11 Aluminium swivel clamp*

- A visual check of clamps includes: Cracks, damage and deformation. All necessary bolts, rounds and nuts are present (inform yourself about the necessary elements). Damage of thread on bolds and nuts split pens or other devices to stop movement are in place.
- Swivels have a permanent connection, if the connection is made with bolts, they are not removable.
- Swivels have no tolerance between the parts when moving.

Pic. 10.2.12 clamp with irremovable bold

Handling clamps

In general clamps are rather robust, but you should

- not drop clamps from heights.
- keep bolds together with the clamp.
- tighten the clamps a bit more than hand tight, but don't force them with a tool.

Shackles

Shackles exist in a wide variety of types, styles, sizes, and fabrications. A shackle is a U-shaped piece of metal fastening device that is secured with a pin through holes in the end of the two arms. The pins can be a bolt (with a nut), a threaded pin (screwing in the body) or a pin with a security device. A shackle can be used to join steels to each other or to other elements like set connection eyes, slings, or chains.

The two most commonly used shackles in the event and theatre sector are the are 'bow' or 'anchor' shackle and the D shackle. The harp shaped, bow or anchor shackle can withstand angled forces. The U or D shackle can only withstand forces straight in line with the shackle's direction.

Pic. 10.2.13 Secured bolt anchor shackle

Pic. 10.2.14 Screw pin anchor shackle

Bow shackles and anchor shackles are terms that are often used interchangeably, as both names refer to a shackle with a larger, rounded "O" shape look. However, a bow shackle typically has a larger, more defined bow area than an anchor shackle. The rounded design of anchor shackles and bow shackles allow them to take loads from many directions without developing significant side load. The larger loop shape of an anchor shackle or bow shackle does reduce its overall strength, but it is also able to handle a larger strap.

Pic. 10.2.15 Secured D shackle

Pic. 10.2.16 D shackle

D-shackles are also known as chain shackles. Both refer to the "D" shape design. A D-shackle is narrower than a bow or anchor shackle and generally has a threaded pin or pin close. This smaller loop is designed to withstand heavy loads in line with the length axis. Sidewards and racking loads may twist or bend a D or chain shackle.

Chain connectors

Chain connectors are C shaped metal fastening devices that are used to connect chains or steels.

Chain connector

Pic. 10.2.17 Chain connector

Carabiners

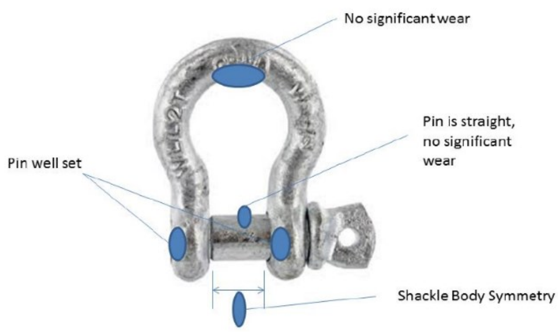
A carabiner is a specific type of shackle. It is a spring-loaded clip device used by climbers and also in stage rigging for smaller, mostly securing purposes.

Pic. 10.2.18 Carabiner

Checking shackles

Shackles should be checked visually on:

- Weight rating and manufacturer's marks
- Thread wear
- Wear and cracks on saddle and pin.
- Pin is straight and properly seated
- Right pen for the right body
- Presence of a nut and safety pen (if applicable)
- Bending and symmetry
- Corrosion



Pic. 10.2.19 checking shackles

Handling shackles

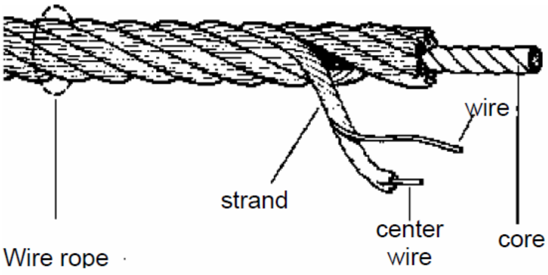
- Despite the fact that shackles, chain connectors and carabiners are rather robust, you should not drop them, to avoid damage on the thread or spring device.
- Don’t use force if the thread doesn't fit.
- Make sure pen and body stay together.

Steels

Steels or steel wire cables are, in stage rigging terminology, prefabricated and certified steel wires with an eye at the end. There are two main purposes for these cables: Hanging and securing.

- In hanging applications, the steel is connected to the supporting structure, the fly bar, … and will **carry the load**.
- In **securing** applications, the steel will not support the load, but will stop it from falling in the event of failure of the primary support. (Some steels contain shock absorbers to limit shock loads.)

The wire rope is constructed like a **twisted rope**, but the strands are made from metal. Always handle steels with care, especially when coiling, to avoid kinks.



Pic. 10.2.20 construction of steel cable

The eye is protected with a **thimble** to avoid damage and ensure optimal connection with shackles etc. Some steels are prepared for specific tasks and have hooks, carabiners or other devices linked directly in the eye.

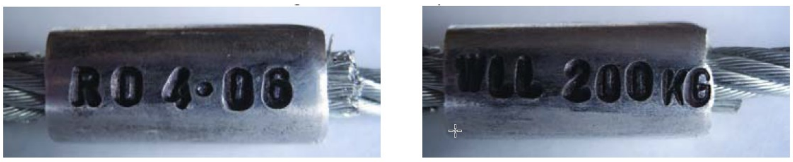
Pic. 10.2.21 eye with timble in steel cable

Both ends are finished with a **thimble**. This is a protective metal or plastic loop used to reinforce and protect the eye at the end of a wire rope. The size is adapted to the properties of the steel wire and the use. The thimble is kept in place by pulling the wire around it and fixing both ends together with a **ferrule** or other fixing part.

The ferrule is a **crimp fitting** in aluminium, brass or steel that is pressed over the cables and joins them irreversibly together. Pressing can only be done with a specialised swagger and is highly specialised work.

Pic. 10.2.22 ferrule

Sometimes the unique identification is pressed in the ferule.



Pic. 10.2.23 ferrule marks

Otherwise a **label** is added to identify the steel. Labels or other ways of marking should at least have a unique identifier, manufacturing date, manufacturer and WLL.

Pic. 10.2.24 Label

Inspection labels should mention last inspection date or expiring date.

Some companies use colour coding, for example with tire wraps, to show the year of inspection.

Some companies use colour coding to show the length.

Different types

Steels are defined by their **properties**:

- WLL or Work Load Limit (expresses the maximum load that should be applied to the steel)
- Section of the cable
- Length
- Eye opening
- Included devices (hook, carabiner, etc.), in other words, the devices that are connected to the steel permanently and irreversibly
- Sleeve, this is a loose protective sleeve of PVC tubing (ideally transparent, to permit examination of the wire rope). The sleeve should be movable to check the cable.
- Black covering, a fixed covering that is made for visual artistic needs.

They also can be defined by their **use**:

- For hanging on fly bars, to make the connection between sets, speakers etc. and the fly bar (in combination with a clamp). These steels are mostly in sight.
- For entertainment rigging, used to hang motors, trusses and other heavy objects or as a second safety.
- Safety cables can be permanent or temporarily fixed on equipment or accessories and function in case of failure of the primary suspension (spot clamps, filter holders, etc.) Sometimes they are also called safety chains, even if made from steel wire.

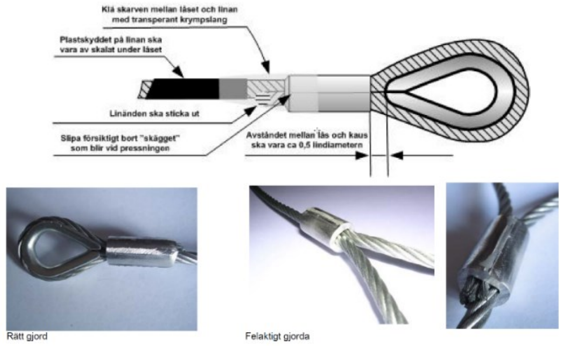
Important remark on safety cables

Safety cables or steels used for secondary safety are calculated to withstand the shock load of the objects that they secure. But once they have encountered a **shock load** they should be decommissioned and replaced!

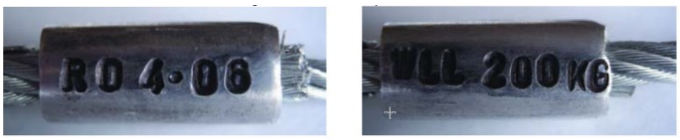
Checking steels

A visual check of a steel includes:

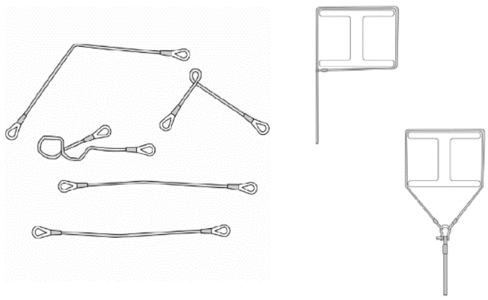
- Threads sticking out of the cable (not necessary a safety issue for lifting, but an issue for handling)
- Broken threads
- Corrosion on the cable
- Kinks
- Strands opening up in a cage-like cluster
- If threads are sticking out of the ferrule far enough to ensure proper fixing
- Loose ferrule
- Cracked ferule
- Loose thimble (indicates slipping ferule)
- Plastic under/in ferrule
- Deformation, burn and stress damage
- Presence of a label



Pic. 10.2.25 What to check on the eye



Pic. 10.2.27 Manufacturer, manufacturing date an WLL in ferule



Pic. 10.2.26 Different types of kinks and deformations

Round slings

A round sling is an **endless** sling made of a coil of fabricated fibres sheathed in a protective synthetic cover. They exist with steel as well as nylon cores. In theatre and event technology, round slings are primarily used to attach trusses to the supporting cables or chain hoists. Round slings can vary in length and WLL.

Round slings made of synthetic fibres like nylon are flexible, soft, light weight and cheap. Due to their material properties, they may only be used for overhead loads if combined with a secondary safety component that has an adequate load-bearing capacity and is made of metal.

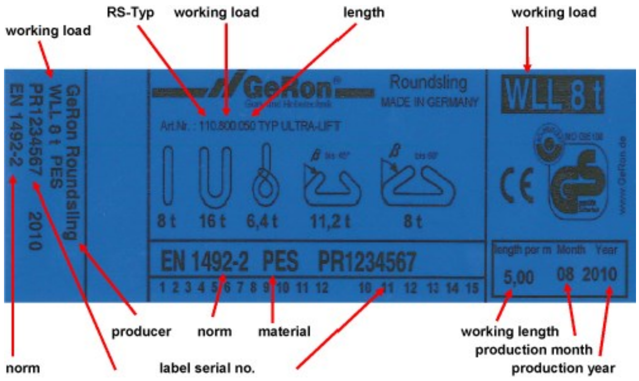
Round slings with a (steel) wire-rope core are less flexible, more expensive and have a stricter bend radius. But they are safer for overhead loads. They don’t have a standardised colour coding. The load baring capacity is specified by the manufacturer.

As an alternative for round slings, band slings are used. These are flat woven slings.

Tags

Every round sling needs to have a tag or label, with the basic information necessary to identify the sling. The label needs to contain at least the following information:

- manufacturer
- loading capacity
- CE marking
- length
- material
- norm / standard
- traceability code
- year of manufacturing

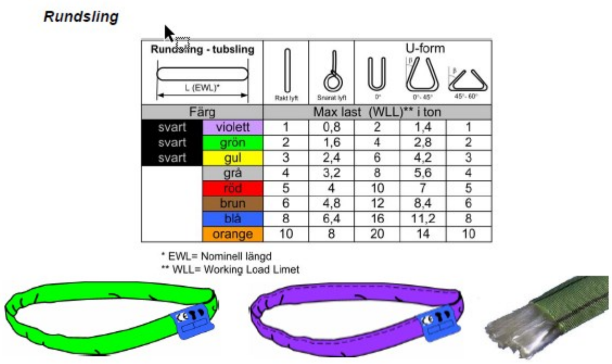


Pic. 10.2.28 sling tag

Round slings without labels must not be used, because we don't have reliable information about their properties. Round slings for holding loads above persons may be loaded with a maximum of 0.5 times the load-bearing capacity specified by the manufacturer (WLL).

Colour coding

For general use, round slings are colour coded, but for the event and theatre industry, they are also produced in black.



Rundsling - tubsling L (EWL)*		Rakt lyft	Snarat lyft	U-form 0°	U-form 0°-45°	U-form 45°-60°
Färg		Max last (WLL)** i ton				
svart	violett	1	0,8	2	1,4	1
svart	grön	2	1,6	4	2,8	2
svart	gul	3	2,4	6	4,2	3
	grå	4	3,2	8	5,6	4
	röd	5	4	10	7	5
	brun	6	4,8	12	8,4	6
	blå	8	6,4	16	11,2	8
	orange	10	8	20	14	10

* EWL= Nominell längd
** WLL= Working Load Limet

Pic. 10.2.29 Colour coding

Checking round slings

Slings have to be checked before use for obvious defects. If these defects impair safety, the slings must be withdrawn from further use. We look for:

- Damaged **sleeve**/jacket, cuts in cover/holes, etc., heat damage, melted
- Damage to **stitching**
- Presence of **label** or identification tag
- **Knots** (used in rigging, not for transport)
- **Kinks** (steel core)
- **Oil, grease** (if in conflict with nylon)

Handling round slings

- Round slings should not be knotted or tied together.
- Don't dry slings near fire and other hot spots. Temperatures of 100 °C must not be exceeded.
- Don't place loads on round slings or straps if they could be damaged as a result.
- Round slings must be stored dry and protected against the effects of weather (especially UV radiation) and aggressive substances (such as solvents).
- No repairs or other modifications may be carried out on round slings.

Slinging is **specialist work**. A rigger will pay attention to protecting the slings when in use. The slings are not placed over edges with a too small a radius ("sharp edges"). The radius (r) of the edges must be larger than the thickness (d) of the round slings. Dimension d is the thickness of the loaded round slings. In the case of sharp edges ($r < d$) or roughening surfaces, the endangered areas of the round slings are protected. This is achieved by a suitable edge protection applied to all sharp edges.

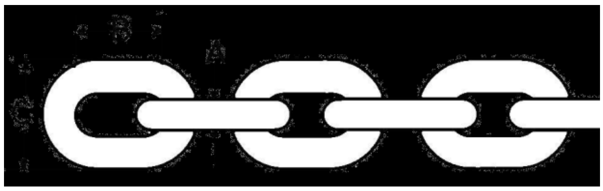
Chains and Hooks

Chains and hooks are a series of, usually metal, links or rings connected to, or fitted into one another and used for various purposes like load bearing and restraining.

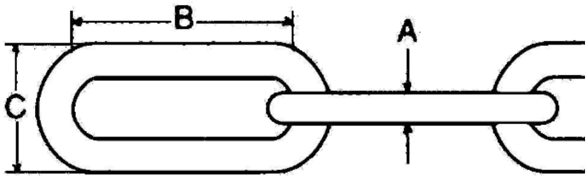
Steel **chains** are offered in many shapes and qualities. For holding loads, only short-link round steel link chains (division T=3 x d; division corresponding to three times the chain link diameter) with welded chain links of proven quality are suitable. Other chains (e. g. hoist chains and lashing chains for securing loads) must not be used as sling chains. Sling chains are marked at least every meter by the manufacturer's chain stamps and the necessary technical information is indicated on a chain tag.

Pic. 10.2.31 Short link chain

Pic. 10.2.33 Long link chain

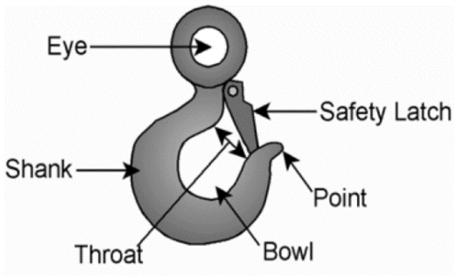


Pic. 10.2.30 short link chain size relation



Pic. 10.2.32 Long link chain size relation

The **hook** is the part that will connect to the sling or to the load. Determining elements are the eye, the shank, the throat, the bowl, the point and the safety latch. Rotating (swivel) hooks are used to guarantee the freedom of movement of the load hook required for safe operation. When using a hook, make sure that the hook doesn't open up.



Pic. 10.2.34 Hook

For the adjustment of the chain length, different types of **chain shorteners** exist. They should only be used for the intended use and in accordance with the manufacturer's information.

Pic. 10.2.35 chain shorteners

Checking chains and hooks

Chains and hooks have to be checked before use for obvious defects. If these defects impair safety, they must be withdrawn from further use. We look for:

- The functionality of safety elements (e. g. locking bolts on chain shortening elements) must be checked before each use.
- Wear and tear
- Cracks or break of a chain link
- Corrosion damage
- Deformation of chain links or chain components

If one of these elements occur, the chain should be discarded.

Chains and hooks have no expiring date, but limits for allowed wear are defined for load bearing chains.

Handling chains and hooks

- Chains must not be knotted.
- Chains must be stored dry to avoid corrosion.

Slinging or attaching chains is specialists' work. A rigger will ensure that:

- Chains are not laid around sharp angled edges to avoid chain links from bending.
- Twisted chains are not used to attach loads.
- Hoist chains are not used as sling chains.

Rope

A rope is a group of yarns, plies, or strands that are twisted or braided together into a larger and stronger form. Ropes have tensile strength and therefore can be used for dragging and lifting. Rope is thicker and stronger than similarly constructed cord, line, string, and twine.

Ropes can be found in a wide variety of natural materials like manila, hemp or sisal, or synthetic materials like Dyneema, Polypropylene, Nylon, Polyester or Aramid. The most important properties are:

- Thickness, a minimum size for easy manipulation and good grip
- Breaking strength, the maximum load without safety factor
- Stretch, how much does the rope stretch when under tension
- Abrasion resistance, resistance against wear and tear
- Twisted or braided, the way the rope is constructed
- Colour, black is often used to hide the rope.

Ropes are used for manual hoisting, as a control rope for counter weight fly bars, as a tag line for guidance, or to climb. The choice of a rope depends on the use, the expected quality and sometimes also personal taste.

Checking ropes

Ropes need to be checked on:

- Abnormal wear
- Powder or grit between strands
- Broken or cut fibres
- Variations in size or roundness
- Discoloration or rotting
- Abrasion
- Kinking or signs of overstressed use

Pic. 10.2.36 Damaged rope

Handling ropes

Ropes have to be handled with great care. They are sensitive to water, oil, and incorrect coiling.

Knotting

To connect ropes to objects or other ropes, they can be knotted or spliced. Every knot has advantages and disadvantages.

Bell test for shackles

Some sectors do a bell test to check shackles:

1. Hang the shackle without the pin on a string.
2. Use a metal object to tap the shackle.
3. A good shackle should ring. If the sound is "hollow" or dull the shackle is suspicious.
4. Now do the same to the pin.

What you need to remember

- The different types of clamps, steels, round slings, chains, shackles and ropes
- The use of clamps, steels, round slings, chains, shackles and ropes
- What to check for different types of equipment

Terms and definitions	Terms and definitions
• stage rigging	• visual defaults
• clamp	• visual inspection
• spot clamp	• unique number
• C clamp	• initial inspection
• swivel clamp	• periodic inspection
• steel cable	• Split pen
• safety cable	• crack
• round sling	• deformation
• chain	• eye
• shackle	• thimble
• anchor shackle	• ferrule
• D-shackle	• hook
• carabiner	• primary suspension
• chain connector	• thread
• rope	• kink

Rehearsal questions

10.02.01 A visual inspection must be done

a) every time you use a safety critical device.
b) only once per year, by a specialised person.
c) only when selling, by the seller.

10.02.02 A periodic inspection can be done by

a) a salesperson.
b) a user.
c) a specialised person.

10.02.03 A safety cable that has encountered a shock load

a) has to be checked.
b) has to be replaced.
c) None of the above

10.02.04 Which clamps are not suitable for trusses? (multiple answers)



A b c

10.02.05 Match

1. D shackle
2. Chain connector
3. Anchor shackle
4. Carabiner




A B C D

10.3 Suspension systems

At the end of this block, you:

- Recognise different suspension systems.
- Understand the functioning of different suspension systems.
- Understand the risks of different suspension systems.

We need to hang or mount equipment, sets and even people in all kind of events or performances. For this purpose, we use suspension systems, mechanical constructions on which performance equipment (sound, light, set, video, …) can be safely suspended. The suspension system is not part of the equipment and can be permanent or temporary. The systems can be fixed or movable.

Almost all suspension systems have a **standard pipe size** of 48 – 50 mm. This allows us to use standardised clamps and other fasteners. In this way, rental or touring equipment fits everywhere.

In the event or theatre sector, suspending equipment means that a load will be hanging (and moving) **above people**. This involves a serious risk that needs to be taken care of. The suspension has to be safe under all conditions, from set-up till wrap-up.

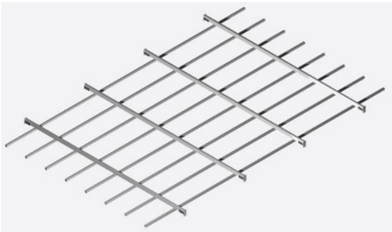
Even if you don't operate the system, you need to know the different types of systems and understand the basic procedures to use them. You will be part of the team that fits and secures the equipment, so you need to know how to do this in a safe way.

Fixed suspension systems

Fixed suspension systems are static, non-moving, constructions that are used to support performance equipment.

Fixed grids

In smaller venues, with a limited height, you will often find fixed grids. These are constructions of (standard size) pipes that are permanently attached to the building. The advantage of such a system is that it is cheap and needs almost no maintenance. The disadvantage is that you need to go up with the equipment and you have to work at height to mount the equipment and make the connections. Most fixed grids have a limited load bearing capacity.



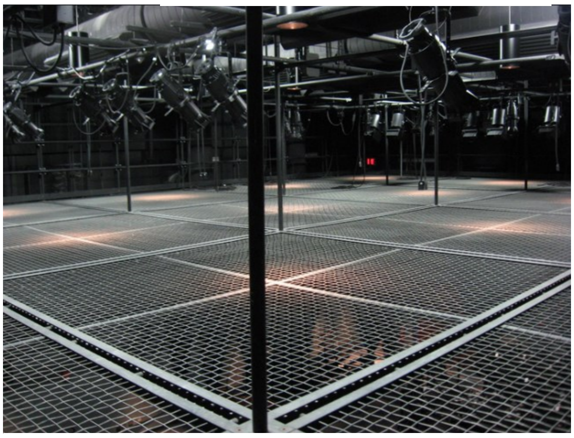
Pic. 10.3.1 Fixed grid

Bridges

Pic. 10.3.2 Working bridge

In larger venues you will often find working bridges. These are permanent constructions that are meant to work on and that have standard pipes and attachment points, reachable from the bridge, to fit the equipment. The advantage of a working bridge is that you can work from a safe and stable floor, but you have to realise you are still working at height. Equipment can fall and if you reach out or stand on the pipes, you can still fall.

Tension grid

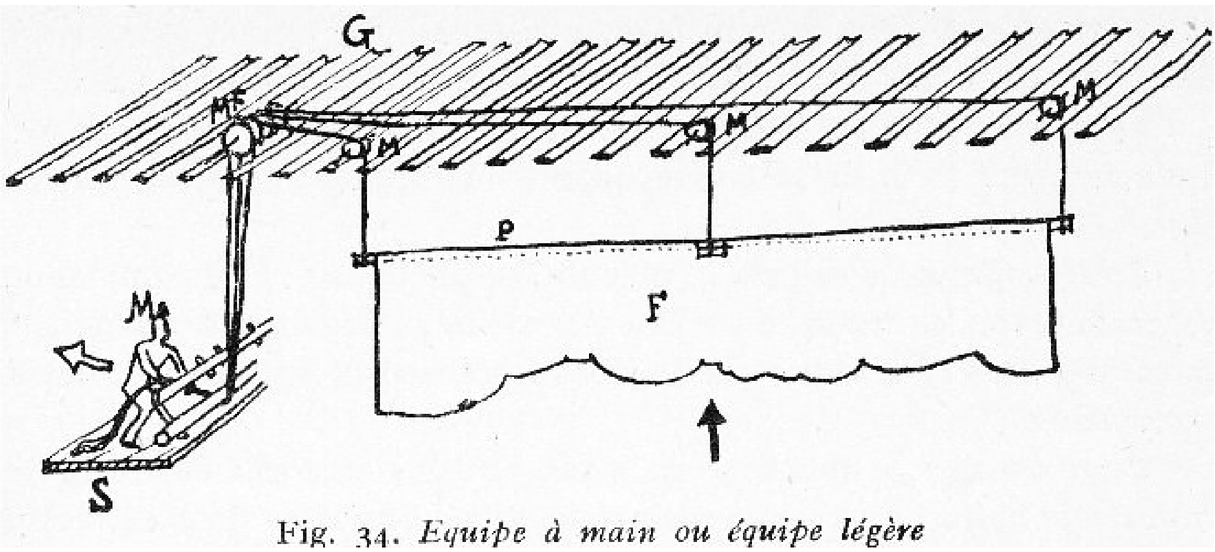


Pic. 10.3.3 Tension grid

A tension grid is a fixed grid with a wire rope net under it. You can walk and work safely on the net. Cables and light can pass through the net. A tension grid is a very flexible system that allows for multiple people to work at height at the same time, without being disturbed by equipment or sets underneath. You have to be very careful because smaller objects can fall through the net. Emptying your pockets and restricting the area below is essential.

Hemp sets

Hemp sets are the oldest known theatre rigging system, and they are still in use in many countries. A hemp house has a permanent floor/grid with openings to pass the ropes through. Pulleys (loft blocks) are placed where ropes need to go. The ropes are connected to a batten or a set piece and are pulled manually. When the load is at height and levelled, the ropes are tied off on a cleat.



Pic. 10.3.4 Hemp set

Larger loads that need to be changed during a show are counter weighted with sand bags or other weights. This way, less force is needed and a smoother movement is possible.

Hemp sets are very flexible. You can choose the place of the loft blocks and the length of the battens. But hemp sets need experienced operators because of the high risks involved. The ropes need constant care to keep their load bearing capacity and the operators need to understand the strength reduction caused by knotting the ropes.

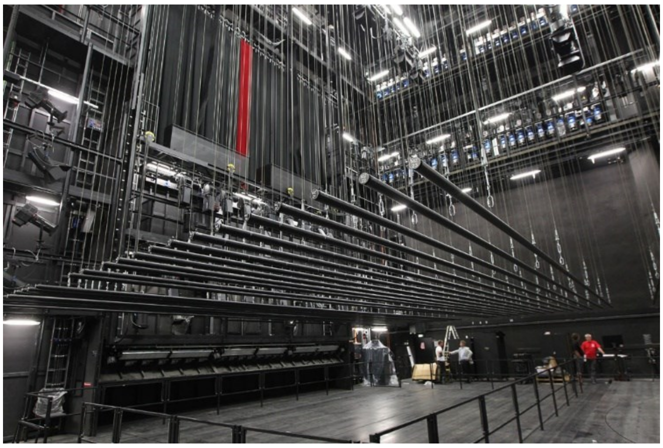
Pic. 10.3.5 Sand bags

The main disadvantage or hemp sets is that they are in constant unbalance and there is no standardised load bearing capacity. The operators need to calculate the load limits on the spot, based on the ropes, knots and battens used. Hemp sets are very labour-intensive, and often require more than one person to operate.

Pic. 10.3.6 Fly loft

Fly bar systems

In most countries, fly bar systems are the standard way of lifting stage equipment and have replaced the traditional hemp sets. Fly bars are metal bars or rods to which sets, soft goods, sound equipment, lighting equipment or other elements can be attached and that can move vertically. The fly bars are suspended on a system that consists of lines, pulleys, counter weights or motors. This fly bar system enables stage crew to fly (hoist, move) the bars quickly, quietly and safely in and out of the sight of the audience.



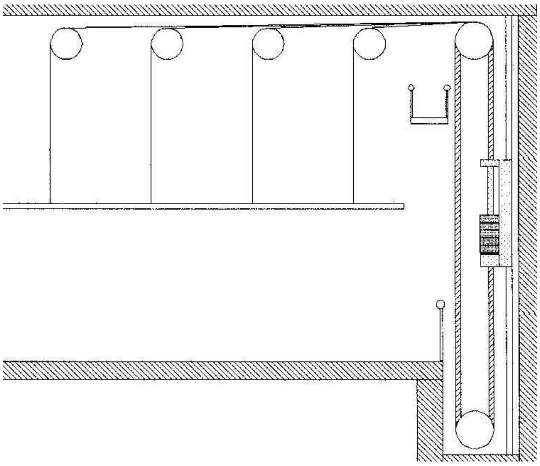
Pic. 10.3.7 Fly bars

Most fly bars hang close to each other, above the stage, parallel to the stage opening, but specific bars can hang front to back or in a specific position. The fly bars can move from approximately 1 m above the stage floor up to the fly floor. A typical fly floor (fly loft) is mounted in the fly tower on a height of 2.5 times the stage opening. In this way, a set that is the full height of the stage opening can disappear completely for the audience.

Fly bar systems can be counter weighted, motorised or automated.

Counterweight fly bar systems

In a counterweight fly bar system, the fly bar is connected, via steel cables and pulleys, to a guided arbour (counter weight holder). Counterweights can be stacked and secured on the arbour to balance the load on the fly bar. The weights are loaded and unloaded on a working gallery or bridge, high up in the tower, because the arbour is up when the load is down. The arbour can be moved with an operating line in a closed loop. The system can be secured by means of locks (breaks) or clamps, but these are only meant to secure the imbalance caused by the weight of the cables and the weight difference between two counter weights.



Pic. 10.3.8 Counterweight fly bar system

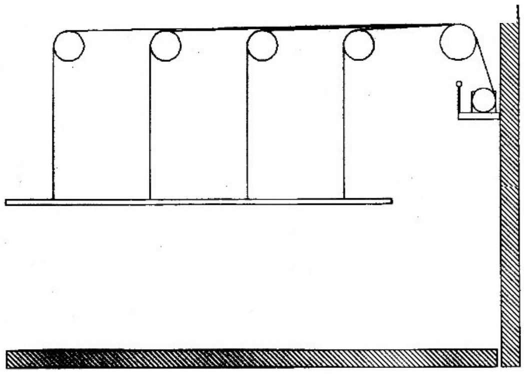
In situations where the wall on stage level needs to stay free, double purchase counter weight systems are used. The travel of the counterweights is halved true the use of a pulley system. The disadvantage of this method is that it needs twice the amount of counterweights.

Counterweight systems are labour intensive due the loading and unloading of the weights. During loading and unloading there are always risks involved caused by the unbalance between the load and the weights.

Pic. 10.3.9 Locks

Motorised fly bars

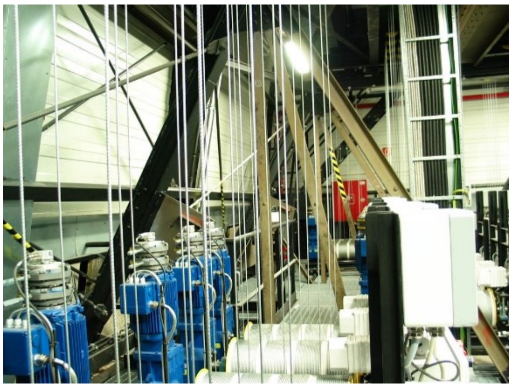
In motorised fly bar systems, the fly bar is connected, via steel cables and pulleys, to a drum which is powered by an electric or hydraulic motor. The motor-drum combination contains a self-locking gear (e. g. worm gear) or an additional brake, which is locked in the idle state. These types of systems cannot be used for changeovers, as they have a permanent speed. You will often find them in smaller venues, where there is no fly tower.



Pic. 10.3.11 Motorised fly bar

Automated fly bar systems

Automated fly bar systems are motorised fly bar systems, with a motion control computer on the motors. The motion controller can be programmed and is able to make complex movements with several fly bars at the same time. The controller measures the exact height, speed and weight of the fly bars and detects errors or riskful situations like a slack cable or overweight. An entire show can be operated by one person.



Pic. 10.3.10 Fly bar motors

Point hoists

Pic. 10.3.12 Point hoists

A point hoist is a motor with a single line. The hoists can be positioned freely on the grid or the line is guided from a fixed motor to a movable point on the grid. The hoists can be controlled in the same way as motorised or automated fly bar systems.

The main advantage of point hoists is flexibility without blocking other hoisting devices. This is especially important when hoisting 3D objects in a complex set.

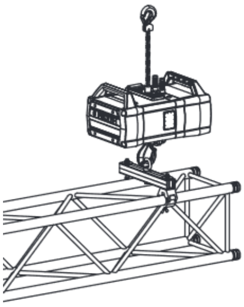
Truss structures

A truss structure (in an entertainment context) is a construction made out of truss elements to temporarily support or hang entertainment equipment. The modular truss elements are made from round, welded tubes and can be connected to each other with standardised couplers. Trusses exist in a wide variety of shapes, sizes, lengths and coupler systems. The construction of trusses consists mostly of triangular shapes, because a triangle is the only geometric shape that retains its shape when exposed to loads. Next to straight lengths of truss, all kind of corners and adaptors are available, which makes the truss structures very flexible to use in different, temporary, circumstances.

There are three main ways to use a truss construction, rigged, free standing or self-supported.

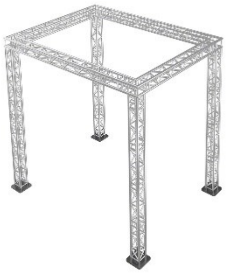
Rigged structures

A rigged structure is a structure that hangs on motors or other attachment points. Typically, chain hoists are used for this purpose. The load on the attachment points has to be calculated carefully and is a complex specialised job. Most chain hoists have a permanent speed, but there is an evolution to automated hoists, that can make movements during a show.



Pic. 10.3.13 Chain hoist

Free standing structures



Pic. 10.3.14 freestanding structure

For smaller constructions, in places where hoisting is not an option or where no loads have to be moved, freestanding structures are used. The structures are mounted first, using lifting equipment. This way of constructing is difficult and has a lot of safety issues. A mounted square is heavy to lift and the leverage can create unacceptable tension in the corners. When the basic square is lifted, the legs must be mounted on height, which can be destabilise the square.

When they are erected and secured, the loads have to be hung on height, which is less safe and very labour intensive. The constructions are mainly used in trade shows, events and festivals, because they are relatively cheap and take up a minimum of space on the ground.

Scaffolding

Scaffolding is used for free standing structures that encounter heavier loads or that are used outside. Especially where people have to walk on the structure (bridges, control boots at festivals, grand stands for audiences, sub-structure for walkable sets) or where heavy forces are involved (speaker towers or mounting of banners) they are a better solution. They are more flexible if you want to build specific constructions and can withstand extreme forces since they are made for building construction purposes.

Ground support systems

When large loads must be lifted, but no hoisting possibilities are available, for example outside, ground support systems are used. This is a truss system consisting of vertical pillars that are erected first and a frame that can be lifted on these pillars. The lifting of the frame is done with chain hoists and pulleys on top of the pillar.

Pic. 10.3.15 Ground support system

What you need to remember

- Safety will always be the result of a balance between usability and acceptable risk.
- A risk is the combination of a dangerous situation or action with the probability that something will go wrong, and the impact it has.
- There is a relation between risks, incidents, accidents and injuries
- The causes of unsafe actions (not knowing, not being able to, not wanting)
- The types of unsafe situations (Organization, Equipment, Circumstances)
- The importance of coincidence in avoiding accidents

Terms and definitions

- standard pipe size
- fixed suspension systems
- fixed grids
- tension grid
- hemp set
- cleat
- loft blocks
- fly loft
- fly bar
- counter weight fly bar system
- double purchase counter weight system
- motorised fly bar system
- changeover
- automated fly bar system
- point hoist
- truss
- coupler
- chain hoist
- scaffolding
- ground support system

Rehearsal questions

10.03.01 A standard pipe size is
a) 38-40mm.
b) 48-50mm.
c) 58-60mm.

10.03.02 True/false

- On a working bridge I stand on the floor, so I don't need to consider good practice for working at height.

10.03.03 A tension grid is used
a) to secure circus artists.
b) to work on.
c) to avoid small objects to fall.

10.03.04 The height of a typical fly loft is
a) 1.5 times the stage opening.
b) 2 times the stage opening.
c) 2.5 times the stage opening.

10.03.05 A fly bar is
a) a system to fly people on stage.
b) a metal bar to hang sets and equipment.
c) a place where machinists can have a break without leaving the fly loft.

10.03.06 The lock of a counterweight fly bar system
a) can secure the weight of the load.
b) can secure the weight of the load plus the counterweight.
c) can secure the weight of the counter weight.
d) can secure the imbalance between the load and the counterweight.

10.03.07 Compared to a single counterweight system, a double purchase counterweight system …
a) needs only half of the amount of counterweight.
b) needs double the amount of counterweight.
c) needs the same amount of counterweight.

10.03.08 A truss is always made out of
a) triangles.
b) squares.
c) circles.

10.03.09 The geometric shape that retains its shape when exposed to loads is the
a) square.
b) circle.
c) triangle.

11 Answers

01.01.01: True

01.01.02: False

01.01.03: False

01.01.04: True

01.01.05: False

01.01.06: False

01.01.07: False

01.01.08: True

01.01.09: False

01.01.10: b

01.01.11: b

01.01.12: True

01.01.13: b

01.01.14: b

01.01.15: False

01.02.01: d, b, a, c, e

01.02.02: c

01.02.03: b

01.02.04: e

01.02.05: d

01.02.06: False

01.02.07: b, c

01.02.08: False

01.02.09: True

01.02.10: False

01.02.11: True

01.02.12: False

01.03.01: b

01.03.02: True

01.03.03: False

01.03.04: True

01.03.05: True

01.03.06: a, c

01.03.07: c

01.03.08: False

02.01.01: b

02.01.02: False

02.01.03: c

02.01.04: a

02.01.05: c

02.01.06: b

02.01.07: a

02.01.08: Your name / The name of the organization / Location / Type of accident and effects / Amount of victims / Directions to get to the place

02.01.09: False

02.01.10: False

02.02.01: False

02.02.02: c

02.02.03: False

02.02.04: b

02.02.05: True

02.02.06: False

02.02.07: False

02.03.01: True

02.03.02: True

02.04.01: False

02.04.02: b

02.04.03: True

02.04.04: True

02.05.01: a2, b3, c4, d1

02.05.02: a

02.05.03: b

02.06.01: b

02.06.02: 1b, 2a, 3c

02.06.03: b

03.01.01: False

03.01.02: False

03.01.03: True

03.01.04: True

03.01.05: False

03.01.06: False

03.01.07: True

03.02.1: True

03.02.2: False

03.02.3: True

03.02.4: False

03.02.5: True

03.03.01: b

03.03.02: False

03.03.03: False

03.03.04: a

03.03.05: b

03.03.06: c

04.01.01: False

04.01.02: b

04.01.03: c

04.01.04: False

04.01.05: a

04.02.01: b

04.02.02: c

04.03.01: 1) Working in workshops, with machines etc. 2) Working with trussing and steel. 3) Performance sound. 4) Pyrotechnics, weapons and special effects

04.03.02: b, c

04.03.03: False

04.04.01: False

04.04.02: b

04.05.01: d

04.05.02: False

04.05.03: True

04.05.04: b, d, e, c, a

04.05.05: False

04.05.06: False

04.05.07: False

04.05.08: b

04.05.09: b

04.05.10: False

04.05.11: False

04.05.12: False

04.05.13: True

04.06.01: 1-b, 2-d, 3-c, 4-a

04.06.02: c

05.01.01: True

05.01.02: False

05.01.03: True

05.01.04: True

05.01.05: False

05.02.01: 1-c, 2-e, 3-d, 4-f, 5-a, 6-b

05.02.02: c

05.02.03: c

05.02.04: c

05.03.01: False

05.03.02: a, c

05.03.03: True

05.03.04: True

05.04.01: 1-a, 2-d, 3-c, 4-b

04.06.02: b

05.05.01 b

05.05.02 b

05.05.03 c

05.05.04: False

05.05.05 b

05.05.06 c

05.05.07 c

05.06.01: 1-d, 2-b, 3-c, 4-a

05.06.02: b

05.07.01 False

05.07.02 False

05.08.01 c

05.08.02 False

05.08.03 b

06.01.01 a

06.01.02 c

06.01.03 b

06.01.04 b

06.01.05 c

06.01.06 False

06.01.07 b

06.01.08 b

06.01.09 False

06.01.10 A-1, B-4, C-3, D-2

06.01.11 b

06.02.01 False

06.02.02 True

06.02.03 c

06.02.03 b

06.02.05 False

06.02.06 b

06.02.07 c

06.02.08 True

06.02.09 a

06.02.10 False

6.02.11 False

06.03.01 c

06.03.02 False

06.03.03 b

06.03.04 c

06.03.05 b

06.03.06 c

06.03.07 a

07.01.01 a

07.01.02 a-4, b-1, c-3, d-2

07.01.03 c

07.01.04 c

07.01.05 b

07.01.06 b

07.01.07 d

07.01.08 c

07.01.09 b

07.01.10 False

07.02.01 b

07.02.02 False

07.02.03 a

07.02.04 b

07.02.05 a

07.02.06 True

07.02.07 True

07.02.08 False

07.03.01 False

07.03.02 b

07.03.03 b

07.03.04 True

07.03.05 c

07.03.06 a

07.03.07 False

07.03.08 a

07.03.09 True

07.03.10 c

07.03.11 c

07.03.12 b

07.03.13 False

07.03.14 c

07.04.01 False

07.04.02 c

07.04.03 c

07.04.04 A-2, B-3, C-1

07.04.05 a

07.04.06 True

07.04.07 True

07.04.08 a

07.04.09 b

07.04.10 b

07.04.11 a

07.04.12 a

07.04.13 b

07.04.14 False

07.04.15 True

07.04.16 False

07.04.17 b

07.04.18 False

07.04.19 False

07.04.20 A-2, B-3, C-1

07.04.21 False

07.04.22 a-2, b-1, C-3

07.04.23 False

07.04.24 False

08.01.01 True

08.01.02 False

08.01.03 False

08.01.04 True

08.01.05 True

08.01.06 False

08.02.01 False

08.02.02 True

08.02.03 False

08.02.04 False

09.01.01 b

09.01.02 False

09.01.03 False

09.01.04 True

09.01.05 c

09.01.06 1-c, 2-b, 3-d, 4-a

09.01.07 False

09.01.08 b

09.02.01 c

09.02.02 False

09.02.03 b

09.02.04 True

09.03.01 False

09.03.02 a

09.03.04 True

09.03.04 True

09.03.05 False

10.01.01 a

10.01.02 b

10.01.03 c

10.01.04 b

10.01.05 c

10.01.06 c

10.01.07 a

10.01.08 b

10.01.09 a

10.01.10 c

10.01.11 b

10.01.12 b

10.02.01a

10.02.02 c

10.02.03 b

10.02.04 A, C

10.02.05 1-B, 2-D, 3-C, 4-A

10.03.01: b

10.03.02: false

10.03.03: b

10.03.04: c

10.03.05: b

10.03.06: d

10.03.07: b

10.03.08: a

10.03.09: c